# Introduction

THE earlier report[1] in this series summarized the research work undertaken by the various University Departments of Agricultural Economics in the first free research period under the reorganized National Investigation into the Economics of Milk Production. This period was followed by two years of costings and then by a further three year period of free research. This report summarizes the research studies carried out during the second research period between 1957 and 1960.

Much of the work undertaken during the second research period was concerned either with studies of feeding practices or with analytical studies seeking to evolve theoretical feeding standards for the dairy herd, and has proved to be materially less readily amenable to a continuous narrative form than before. For this reason, the report does not attempt to correlate the various conclusions that have been made.

The studies which are summarized in the report have been largely concerned with the various aspects of feeding dairy cows. These have been subdivided into three groups, Feeding Standards, Feeding Practices and Grass, included under the section Feed Economy which forms the major part of the report. This is followed by sections on three important points of management, namely, Seasonality of Milk Production, Herd Replacements and Self Feeding Systems for Silage; there is a section on Cheesemaking and one demonstrating the use of Linear Programming as a planning technique for the dairy farm. The report concludes with two sections discussing the present pattern of dairy farming and recent trends in milk production.

# I. Feed Economy

## FEEDING STANDARDS

The studies which are summarized in this report have been largely concerned with various aspects of feeding dairy cows. This emphasis on studies of feeding practices is, of course, a reflection of the importance of feeding as economically as possible to obtain maximum profits from a dairy herd.

Feeding efficiency is especially important on the smaller farms. On the majority of small farms up to 60 or 70 acres, where high output is achieved by heavy use of concentrates for the dairy herd and substantial pig and poultry enterprises, the cost of purchased feed is more than the total of all other costs. This fact was highlighted in a study of small lowland dairy farms in Wales.[2]

A simple measure of efficiency was put forward which small dairy farmers could apply to their farms. Based on Welsh conditions the results suggested that the standard was: "the gross output per acre should equal 1½ times the cost of feed purchases per acre plus £26". For example, if on a farm of 50 acres the total amount spent on purchased feed was £1,000, or £20 per acre, then a reasonable estimate of the gross output that one might expect to obtain on a farm with average management would be (1½×20)+£26=£56 per acre.

In reverse this formula gave an estimate of average requirements for purchased feed per acre: £⅔(gross output per acre −26). A small sample of Welsh farms was divided into three equal groups according to profitability per acre. The most profitable group used 10 per cent less feed than was indicated by the standard, whereas the least profitable farms used about 40 per cent more. Obviously, small farms may be met with where this rough and ready guide will not reflect a true relationship between output and requirements for purchased feed. However, when it was applied to a small sample of dairy farms in north-west England, the results showed it to be widely applicable.

In addition to analyses of its effect on the general profitability of the small farm, the feeding economy of a dairy herd has been studied in greater detail from two viewpoints; firstly, studies have been made of current feeding practices, both in different parts of the country and according to differing systems of production, and secondly, there have been long-term analyses of current practice which aim at discovering the scientific relationship between input of feed and the production of milk and evolving from this a set of practical feeding principles.

Jawetz[3], in his work, has followed the second avenue. Conventional feeding standards have been newly evaluated and attempts have been made to find reliable relationships between the input of protein and starch and the output of milk for cows of different weights, breed, and age, etc. A study carried out in Scotland by Dr. Blaxter showed that the response to food was greater in high yielding cows than in low yielders, and this relationship held good at different stages in their lactations. It was found that low-yielding cows gave responses of less than 0·5 lb per lb milk Starch Equivalent where high yielding cows gave over 2·2 lb milk.

Working from the results of the National Investigation into the Economics of Milk Production for Bristol I Province (1949), Jawetz evolved a new theory of feeding dairy cows according to production. He studied the conversion ratios of feed into milk, with particular reference to the interrelationships of starch, protein and yield. The basic data for this survey was derived from a comparatively small number of complete herds; it was not collected for the purpose of this study, and had other defects. The conclusions derived from the material should therefore be interpreted with care.

From the comparison of the inputs of nutrients per gallon of milk in Shorthorn, Friesian and Ayrshire herds studied, Jawetz concluded that breed was the main explanatory variable of the feed input-milk output ratio. He then proceeded to study the substitution of Starch Equivalent for Protein Equivalent in different herds and at varying yield, and found for Friesians a fairly constant rate of substitution (roughly 5 lb S.E. for 1 lb P.E.) at both low and high levels of feeding. For Shorthorns at high levels of feeding 1 lb P.E. could replace up to 12 lb S.E. Jawetz applied the results of this substitution analysis to the determination of the composition of the standard dairy ration, and suggested that at 1960 prices the "mix", with 62·5 per cent S.E., should contain rather more P.E. (e.g. 15·7 per cent for Friesians) than the normal 13·25 per cent. The extra cost of the P.E. would be outweighed by a reduction in the amount per gallon needed at both high and low yields.

### *Yield Capacity*

Theoretically, profit in milk production is maximized when the cost of extra cake fed is equal to the value of the extra milk produced—if the price of milk is 36*d.* per gallon and cake is 3·6*d.* per lb, production can continue profitably until the marginal 10 lb cake produces exactly one extra gallon of milk. The level of production at which this 10 lb forms the marginal input of feed depends on the genetic yield potential of the individual cows. If this potential is known it is possible to budget to determine whether it is profitable to purchase the expensive high yielding cow or a less costly average yielder. Jawetz provided a budget to show that the more expensive cow was the best buy under the circumstances given.

Jawetz then examined the question of feeding according to yield capacity instead of to conventional standards. He constructed varying lactation curves, which were based on different yields at peak production, on the assumption that estimates of total yield capacity could be based on the peak output figure. Total lactation yield would be lowered by not feeding sufficiently to force peak production to yield potential, and such feeding would be well above conventional levels per gallon.

Given that yield propensity can be altered by varying feeding levels, the marginal economic feed input depends on the price situation. Where the marginal quantity of output is half a gallon, the following formula will show the "best" or highest economic marginal input:

$$\frac{\text{Price of one half gallon milk}}{\text{Cost of 1 lb concentrates}}$$

The following table demonstrates the marginal inputs in different price situations:

TABLE I. *Highest economic marginal input per half-gallon at different prices of milk and concentrates (Regardless of the level of yields higher marginal inputs than those given below would not pay)*

| When price of half-gallon milk is | When price of cake per ton and per lb is | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | £39·2<br>4·2*d.* | £37·3<br>4·0*d.* | £35·5<br>3·8*d.* | £33·6<br>3·6*d.* | £31·7<br>3·4*d.* | £29·9<br>3·2*d.* | £28·0<br>3·0*d.* | £26·1<br>2·8*d* |
| | Highest economic marginal inputs of cake per half-gallon output | | | | | | | |
| *d.* | lb | lb | lb | lb | lb | lb | lb | lb |
| 21 | 4·8 | 5·2 | 5·6 | 5·8 | 6·2 | 6·6 | 7·0 | 7·4 |
| 20 | 4·6 | 5·0 | 5·2 | 5·6 | 5·8 | 6·2 | 6·6 | 7·0 |
| 19 | 4·4 | 4·8 | 5·0 | 5·2 | 5·6 | 6·0 | 6·4 | 6·8 |
| 18 | 4·2 | 4·6 | 4·8 | 5·0 | 5·2 | 5·6 | 6·0 | 6·4 |
| 17 | 4·0 | 4·2 | 4·4 | 4·6 | 5·0 | 5·4 | 5·6 | 6·0 |
| 16 | 3·8 | 4·0 | 4·2 | 4·4 | 4·8 | 5·0 | 5·4 | 5·8 |
| 15 | 3·6 | 3·8 | 4·0 | 4·2 | 4·4 | 4·6 | 5·0 | 5·4 |
| 14 | 3·4 | 3·6 | 3·8 | 4·0 | 4·2 | 4·4 | 4·6 | 5·0 |
| 13 | 3·0 | 3·2 | 3·4 | 3·6 | 3·9 | 4·0 | 4·4 | 4·8 |
| 12 | 2·8 | 3·0 | 3·2 | 3·4 | 3·6 | 3·8 | 4·0 | 4·4 |
| 11 | 2·6 | 2·8 | 2·8 | 3·0 | 3·2 | 3·4 | 3·6 | 4·0 |
| 10 | 2·4 | 2·6 | 2·6 | 2·8 | 3·0 | 3·2 | 3·4 | 3·8 |

For Friesians, with purchased cake at 3·6*d.* per lb and milk at 38*d.* per gallon, Jawetz calculated that the highest economic daily input per cow would range from 22 lb to 32 lb according to yield. The best daily input would be from 2·7 lb to 3·9 lb of cake higher, depending on yield capacity, than when the price of milk was 31*d.* per gallon.

Determining the most profitable input from a practical point of view is further complicated by differential prices for summer and winter milk. If a cow's peak lactation coincides with low milk prices, it may be worth feeding to an uneconomic level in the short-run to ensure that the full yield potential will be realized, and there will be more milk to sell, at a higher price, later in the season.

The following conclusions drawn by Jawetz from his detailed analysis hold implications for the practical dairyman:

*a.* "Diminishing rates of nutrient substitution mean that the best balance of S.E. and P.E. in cakes and mixtures is not constant, but varies with the relative prices of S.E. and P.E. in the form of straight concentrates." At 1960 prices it would appear that the most economic balance in ordinary cake of 62·5 per cent S.E. would be achieved with about 15 per cent P.E. instead of the prevailing 13·25 per cent. The saving in weight would amount to about 8 per cent, whereas the cost per lb would increase by only a fraction.

*b.* "The higher the yield capacity of a cow the better is her productivity, i.e., the lower is the input necessary for a given output." At low yields, towards the end of a lactation, requirements seem to be below the conventional level of 4 lb per gallon. At high yields, however, and when cows with a limited potential are pushed towards high yields, up to 50 per cent more cake may be required.

*c.* "It would appear that, as between cows of similar yield capacity, Friesians have a higher productivity (i.e., conversion rate of feed to milk) than Shorthorns at highest levels of yield, whereas the latter may have a slight advantage over Friesians at lower yields." "The advantage of Friesians over Shorthorns becomes greater as the price of milk rises and/or the (nutrient) cost of concentrates falls."

*Research on feeding Dairy Cattle based on Bull Progeny Tests.*

Some statistical analysis was carried out by Gardner[4] on experimental results of B.O.C.M. Bull Progeny Tests. These tests, designed to evaluate the differences between groups of dairy heifers sired by different bulls, measured milk yield against feed input. Firstly Gardner analysed the response to an increase in S.E. consumption and concluded that a 1 lb increase in S.E. consumption was associated with an extra milk yield of 3·5 lb for Friesians, 3·23 lb for Shorthorns, and 2·56 lb for Ayrshires. If these results could be taken as standards, cake could still be fed even at higher levels of total S.E. consumption than are usually considered profitable, since the price received for milk would exceed the marginal feed cost. However, Gardner concluded that the variations between individual cows were such that the evidence from this type of analysis did not justify any assumption to be made about the response of any particular cow to any particular level of feeding.

Gardner studied the relationship between milk output and change in live weight. It appeared from this analysis that an increase in live weight for an individual cow was normally associated with a fall in milk yield. On the other hand, cows with a larger capacity for food, not necessarily those with a high bodyweight, tended to give a greater marginal return in milk, which indicated that good appetite and good conversion of food to milk may go together. The following tentative conclusions are of interest to the farmer.

"There is certainly varying ability amongst cows to make use of food for milk production. To some extent this reflects their differing utilization of food for milk or meat production. Under current circumstances there may be some danger to the national dairy herd if milk producers cultivate stock which fattens readily for the beef market.

"Selection of stock for economic milk production ought to be based as much on efficiency of food conversion as upon level of milk yield. Only if the inefficient converter will produce milk satisfactorily on cheaper sources of food will it have an economic claim to survival. On this aspect comparative studies of different breeds may be relevant. To the farmer with limited acreage, both good yields and efficient conversion of food would seem to be essential requirements of his dairy stock."

## FEEDING PRACTICES

*Central Somerset Grassland Farms**

A study of feeding practice on 16 grassland dairy farms in central Somerset was carried out by Dench and Mitchell of Bristol University.[5] These farms are on land typical of the low-lying area in the valleys of the River Axe and the River Brue, and of the slightly higher ground of the Panborough Ridge between. The average size of the farms studied was 69 acres (more than three-quarters were less than 100 acres) and the management of most was complicated by fragmentation. Over 90 per cent of the total acreage was under permanent grass, and small acreages of kale, roots, cereals and leys were grown. Dairying was overwhelmingly the most important enterprise. Estimates, based on the 1955 Annual Returns, showed that on two-thirds of the 464 farms in the area the gross output of all non-dairying enterprises was less than 10 per cent of that of the dairy enterprise. Hay was the principal bulk feed of the district, being made on all farms in the sample with yields usually from 27 to 32 cwt per acre. The amount of silage made varied according to the season, and the silage was not usually of a high quality. All farmyard manure was spread, much of it on the grassland but total fertilizer use was low and over the whole area of grass the average cost of manures was 12*s*. 6*d*. per acre.

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* A further report entitled "The Central Somerset Lowlands" (The Importance and Availability of Alternative Enterprises in a Predominantly Dairying District) by G. F. C. Mitchell, University of Bristol, was published in September, 1962.

The primary object of this study was to discover both the facts and the motivation behind current feeding practice, for these farms. With regard to bulky foods there was no predetermined feeding plan on the majority of farms. "The type and quantity of the ration was based on past experience and adjusted in the light of the cow's condition and appetite." The bulk foods actually fed were, however, remarkably close to the theoretical requirements.

### *Feeding of Concentrates*

The rationing of concentrates, mainly purchased compounds, also reflected this rather arbitrary approach. Since only 8 herds had reliable milk records, rationing by yields was largely precluded. However, the farmer who was in daily contact with his herd, would have a reasonable idea of the yield of an individual cow at any stage of the lactation and would ration accordingly. This rationing was frequently by means of a scoop, bowl, skip or bucket, the capacity of which was known to the farmer. Precision in feeding was largely therefore a matter of chance in these herds. The amounts fed per gallon were further complicated by such practices as feeding every cow a certain ration to entice her into the bail, or to keep low yielders quiet in winter stalls and of feeding light yielders relatively more per gallon than heavy yielders, as there was a psychological aversion to feeding more than a certain amount even to high yielders. Some farmers also tended to feed more per gallon when a number of cows were nearing the end of their lactation in order to keep up the milk cheque.

The physical results showed an average consumption of concentrates per cow per year of 13·1 cwt per cow although this varied from 3·7–20·6 cwt. However, excluding the extremes, most farms fed between 7 and 15 cwt per cow. Of this amount of concentrates 71 per cent was fed during the winter period, from November–April. During the summer months April–July, an average of about 1 lb per gallon was fed. The level of feeding over the winter period in 1960 was as follows:

TABLE 2. *Average milk yield per cow, concentrate consumption* per cow and per gallon. Cows in milk. Winter feeding period 1960*

| | Yield per cow | Concentrate per cow | Consumption per gallon |
|---|---|---|---|
| | *Gallon* | *Cwt* | *lb* |
| Herds with above average yields | 506 | 14·5 | 3·2 |
| Herds with below average yields | 380 | 10·4 | 3·1 |
| All herds | 443 | 12·4 | 3·2 |

* Includes concentrates fed for steaming-up.

Variations in feeding practice from month to month within the winter and summer periods were also noticable, as shown by the following table.

TABLE 3. *Monthly variations in the quantity of concentrates consumed by cows in milk per gallon of milk produced in milk recorded and non-recorded herds*

| | Concentrates fed per gallon | |
|---|---|---|
| | Six herds keeping N.M.R. | Ten non-recorded herds |
| 1960 | lb | lb |
| *Winter feeding period* | | |
| January | 3·6 | 3·5 |
| February | 3·7 | 3·0 |
| March | 3·6 | 2·8 |
| April (part) | 3·5 | 2·6 |
| *Summer feeding period* | | |
| April (part) | 1·1 | 0·7 |
| May | 1·1 | 0·4 |
| June | 1·2 | 0·4 |
| July | 1·3 | 0·5 |
| August | 1·4 | 0·7 |
| September | 1·6 | 1·0 |
| October | 2·2 | 1·6 |
| November | 2·4 | 2·0 |
| *Winter feeding period* | | |
| November | 3·6 | 3·0 |
| December | 4·2 | 3·1 |

The figures show that "whereas recorded herds maintained an even rate of feeding per gallon, the average rate on non-recorded herds fell by about 1 lb per gallon from January to April. It is thought that this is not entirely due to lack of knowledge of the yields of fresh calvers in non-recorded herds but rather that some farmers were reluctant to feed heavy quantities of cake per cow at a time when the milk was coming most readily as a result of unassisted physiological processes. During midwinter generous feeding of cake per gallon did not mean that large amounts of cake were used in total, for few cows were in milk and yields per cow were generally low. In March and April, however, the majority of cows were in milk and yields were rising. To maintain the previous rate of concentrate feeding per gallon would therefore have resulted in the use of large quantities of cake per month and this consideration probably had an important influence on the farmer's attitude to rationing during this period."

### *Seasonality of Production*

These farms had a marked bias towards summer milk production, with 64·2 per cent of annual production being produced between April and September. 58·8 per cent of total calvings were in the period January–April, as many as 22·3 per cent of the cows calved in the month of February alone. The whole system of milk production in "the Flats" depended on maximum utilization of summer grazing and on cheap winter rations. These objectives were best achieved by having the main batch of calvings in the January to March period so that the first flush of milk realized winter prices and a fairly high output could be maintained chiefly off grass until late summer. There appeared to be no economic advantage to be gained from a secondary peak of autumn calving; however, the need for a fairly even spread of income might lead farmers to adopt this calving schedule.

### *Winter Feeding*

In view of the somewhat haphazard rationing practices the authors compared the total amounts fed and the theoretical requirements for herds of the same daily yield; see Table 4. Only three herds, during the winter feeding period, were fed a ration which was deficient in theoretical Starch Equivalent requirement. On the other hand, the surplus of S.E. ranged from 0·1–3·2 lb per cow, the latter occurring in a high-yielding herd fed a large amount of concentrates. With regard to theoretical requirements of protein the position was different, one-half of the herds in the sample were deficient in this nutrient by amounts ranging from 0·02–0·26. All these herds were producing some part of the daily milk output from bulky foods and the deficiency in protein could be closely related to this proportion, and the protein analysis of the hay fed. A theoretical deficiency of P.E. was usual in herds which produced 20–50 per cent of their milk from bulky foods, when hay formed a large part of the food input. In some herds a deficiency in protein may have been partially corrected by a surplus of S.E. (see Jawetz). The only two herds in the sample producing over 1,000 gallons per cow a year both fed generously above standard requirements; the authors commented that this tended to bear out the assertions of some authorities that standard requirements were inadequate at high yields.

### *Summer Feeding*

To study the dependence of herds in the sample on grass and the nutrients which were obtained from grazing, a similar analysis was carried out for the summer feeding period. Based on the residual method, Table 5 shows the dependence of herds on grazing for each of the nutrients. In all but two herds the percentage of Protein Equivalent requirement supplied by grazing was less than for Starch Equivalent. This was a reflection of the average quantity of dairy cake, with its high protein content, fed per gallon. However, some wastage of the Protein Equivalent available from grazing was also indicated by the ratio of S.E. to P.E. utilized from grazing. This should, theoretically approach 6·7:1 for the lowest yielding herd. Since the average ratio in grass over the grazing season was in the region of 6–6·5:1 it was clear that some wastage was taking place. It appeared, therefore, that there was some scope for a further limiting of summer cake feeding, especially in herds which only yielded up to about 600 gallons in this period. Several co-operating farmers admitted that cake was fed largely to entice cows into the bail. If some other method could be devised this would reduce cost, as would feeding a cheaper ration at this time.

### *Grassland Productivity*

In order to measure grassland production the Utilized Starch Equivalent was calculated firstly per acre of grazing devoted to milk production, and secondly per acre of all grassland devoted to dairy cows. The U.S.E. per

TABLE 4. *Theoretical requirements and estimated nutritive value of average daily rations fed to cows in milk during the winter feeding period*

| Code No. | Breed | Average daily production per cow in milk | Starch Equivalent |  |  | Protein Equivalent |  |  | Dry matter fed | Per cent of milk from bulky foods |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Theoretical requirement | Fed | Surplus (+) Deficiency (−) | Theoretical requirement | Fed | Surplus (+) Deficiency (−) |  |  |
|  |  | *Gal* | *lb* | *lb* | *lb* | *lb* | *lb* | *lb* | *lb* | % |
| F 20 | Friesian | 3·0 | 14·5 | 17·7 | +3·2 | 2·25 | 2·88 | +0·63 | 34 | Nil |
| F 21 | Friesian | 3·2 | 15·0 | 17·9 | +2·9 | 2·35 | 2·58 | +0·23 | 35 | 12 |
| F 3 | Friesian | 3·6 | 16·0 | 16·0 | — | 2·55 | 2·36 | −0·19 | 29 | 18 |
| F 17 | Mainly Shorthorn | 3·2 | 15·0 | 15·9 | +0·9 | 2·35 | 2·09 | −0·26 | 32 | 36 |
| F 4 | Friesian+Guernsey | 2·5 | 13·0 | 15·0 | +2·0 | 1·97 | 2·63 | +0·66 | 30 | Nil |
| F 12 | Ayrshire+Friesian | 3·1 | 14·5 | 14·6 | +0·1 | 2·27 | 2·13 | −0·14 | 32 | 41 |
| F 5 | Mixed | 1·7 | 11·0 | 13·9 | +2·9 | 1·57 | 2·16 | +0·59 | 29 | 31 |
| F 2 | Friesian | 2·2 | 12·5 | 12·7 | +0·2 | 1·85 | 1·76 | −0·09 | 28 | 48 |
| F 10 | Shorthorn | 3·0 | 14·5 | 16·0 | +1·5 | 2·25 | 2·15 | −0·10 | 30 | 21 |
| F 11 | Friesian+Ayrshire | 2·8 | 13·8 | 13·6 | −0·2 | 2·12 | 2·08 | −0·04 | 27 | 36 |
| F 1 | Mainly Friesian | 2·9 | 14·3 | 14·5 | +0·2 | 2·20 | 2·27 | +0·07 | 28 | 11 |
| F 14 | Friesian | 2·5 | 13·3 | 11·6 | −1·7 | 2·00 | 1·98 | −0·02 | 24 | 26 |
| F 19 | Friesian+Shorthorn | 2·5 | 13·3 | 11·3 | −2·0 | 2·00 | 1·93 | −0·07 | 27 | 49 |
| F 7 | Shorthorn+Friesian | 2·0 | 12·0 | 14·3 | +2·3 | 1·75 | 2·25 | +0·50 | 29 | Nil |
| F 25 | Mixed | 2·2 | 12·5 | 13·5 | +1·0 | 1·85 | 2·10 | +0·25 | 28 | 8 |
| F 18 | Shorthorn | 2·4 | 13·0 | 13·4 | +0·4 | 1·95 | 2·12 | +0·17 | 27 | 37 |
| Average |  | 2·7 | 13·6 | 14·5 | +0·9 | 2·08 | 2·22 | +0·14 | 29 | 23·4 |

TABLE 5. *Estimated total nutritive requirements of cows in milk during the summer feeding period and the proportion supplied by grazing*

| Code No. | Breed | Average Production per cow | Starch Equivalent per cow | | | | Protein Equivalent per cow | | | | Ratio of SE to PE utilized from grazing |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Theoretical requirement | Obtained from hand-fed foods | Utilized from grazing | | Theoretical requirement | Obtained from hand-fed foods | Utilized from grazing | | |
| | | | | | Total | Per cent of requirements | | | Total | Per cent of requirements | |
| | | *gal* | *cwt* | *cwt* | *cwt* | % | *cwt* | *cwt* | *cwt* | % | |
| F 20 | Friesian . . | 735 | 30·9 | 13·9 | 17·0 | 55 | 4·64 | 2·79 | 1·85 | 40 | 9·2 |
| F 21 | Friesian . . | 695 | 30·0 | 7·8 | 22·2 | 74 | 4·46 | 1·35 | 3·11 | 70 | 7·1 |
| F 3 | Friesian . . | 625 | 28·4 | 4·8 | 23·6 | 83 | 4·15 | 0·78 | 3·37 | 81 | 7·0 |
| F 17 | Mainly Shorthorn . | 613 | 28·2 | 3·2 | 25·0 | 89 | 4·10 | 0·58 | 3·52 | 86 | 7·1 |
| F 4 | Friesian+Guernsey | 612 | 27·7 | 2·8 | 24·9 | 90 | 4·03 | 0·48 | 3·55 | 88 | 7·0 |
| F 12 | Ayrshire+Friesian . | 590 | 27·2 | 0·3 | 26·9 | 99 | 3·93 | 0·06 | 3·87 | 98 | 7·0 |
| F 5 | Mixed . . . | 634 | 28·1 | 2·0 | 26·1 | 93 | 4·13 | 0·39 | 3·74 | 90 | 7·0 |
| F 2 | Friesian . . | 647 | 28·9 | 4·0 | 24·9 | 86 | 4·25 | 0·71 | 3·54 | 83 | 7·0 |
| F 10 | Shorthorn . . | 584 | 27·5 | 3·8 | 23·7 | 86 | 3·96 | 0·61 | 3·35 | 85 | 7·1 |
| F 11 | Friesian+Ayrshire . | 548 | 26·7 | 3·7 | 23·0 | 86 | 3·80 | 0·53 | 3·27 | 86 | 7·0 |
| F 1 | Mainly Friesian . | 585 | 27·5 | 2·6 | 24·9 | 91 | 3·97 | 0·51 | 3·46 | 87 | 7·2 |
| F 14 | Friesian . . | 584 | 27·5 | 1·1 | 26·4 | 96 | 3·96 | 0·21 | 3·75 | 95 | 7·0 |
| F 19 | Friesian+Shorthorn | 585 | 27·6 | Nil | 27·6 | 100 | 3·97 | Nil | 3·97 | 100 | 7·0 |
| F 7 | Shorthorn+Friesian | 520 | 26·1 | 4·5 | 21·6 | 83 | 3·68 | 0·88 | 2·80 | 76 | 7·7 |
| F 25 | Mixed . . . | 568 | 27·2 | 6·0 | 21·2 | 78 | 3·89 | 1·11 | 2·78 | 71 | 7·6 |
| F 18 | Shorthorn . . | 428 | 24·0 | 2·0 | 22·0 | 92 | 3·27 | 0·37 | 2·90 | 89 | 7·6 |
| Average | | 597 | 27·7 | 3·9 | 23·8 | 86 | 4·01 | 0·71 | 3·30 | 82 | 7·2 |

acre of grazing ranged from 9·4–18·9 cwt, with an average of 14·7 cwt; this was largely a function of the density of stocking and of concentrate use. The average U.S.E. per acre of all grassland was 16·1 cwt, with a range from 11·4–19·4 cwt.

The actual level of production was quite surprisingly high when it was remembered that only 12*s.* 6*d.* per acre was spent on fertilizers and that 91 per cent of the grassland concerned was permanent pasture. When the classification of forage producers used by the Committee on Grassland Utilization was applied, the sample was classified as follows:

| | |
|---|---|
| Low producers (less than 12 cwt S.E. per acre) . . . . | 2 |
| Medium producers (12–16 cwt of S.E. per acre) . . . | 7 |
| High producers (over 16 cwt of S.E. per acre) . . . | 7 |

*Costs and Returns*

The following table shows the total food cost divided into concentrates, bulk feed and grazing, for 14 of the farms in the sample, grouped according to relative cost of total foods (1960):

TABLE 6. *Cost of concentrates, bulk foods and grazing for four groups of farms classified according to relative cost of total foods 1960*

| | Annual cost of foods per cow in herd | | | |
|---|---|---|---|---|
| | *Total foods* | *Concentrates* | *Bulk foods* | *Grazing* |
| Relative Classification | £ | £ | £ | £ |
| High | 63·1 | 34·7 | 14·6 | 13·8 |
| Medium to high | 49·5 | 20·7 | 15·3 | 13·5 |
| Medium to low | 43·6 | 18·3 | 12·9 | 12·4 |
| Low | 39·2 | 11·3 | 12·1 | 15·8 |

In the sample as a whole the cost of concentrates formed the greatest part of the food cost per cow, although the consumption per cow varied considerably. Excluding two farms, one with a very high and one with a very low per capita consumption, the range in the concentrate consumption was from £11–£33 per cow with an average of £20. For bulky foods the average cost (excluding one farm) was £13·2 per cow, with a small range from £11·3–£16·7. In general, farms with a higher than average consumption of concentrates tended to have also a higher bulk feed cost per cow.

*Margin per Cow*

Margin per cow was strongly linked with returns; where yields, and hence returns, were high, margins tended to be above average. Yield of milk and cost of food were also inter-related. "The allocation of cause and effect in this relationship must, to some extent, be a matter of opinion. Higher yielding cows require greater quantities of concentrates and their food costs are, consequently, higher. But the extent to which milk yield per cow is determined by the level of concentrates feeding is less certain. Most, if not all, farms in the Survey could probably have increased yields by heavier concentrate feeding but it is the writer's opinion that the majority of herds were being fed to the point where increased use of concentrates alone would have resulted in rapidly diminishing marginal returns of milk."

Although, in theory, it would be most profitable to push the consumption of concentrates to the point where the extra milk produced equalled the cost of the extra food fed, in practice this equilibrium is nearly impossible to achieve for any length of time and may not be attempted for management reasons. For instance, at the prices then ruling, it would have paid these farmers to feed 8 lb of concentrates for the marginal winter gallon. "..... the admitted difficulties in arriving at a perfect balance between the level of feeding and the level of milk yield should not deter farmers from experimenting in order to test whether a better relationship than the one practised is possible. In this regard they may not have appreciated that given the usual system of milk production practised in the district all costs, other than that of concentrates, may be regarded as fixed and, therefore, be ignored in such experiments. It is sufficient only to test the relationship between an additional quantity of milk produced and the costs incurred to produce this milk. Provided that the latter value is greater than the former, some margin has been added to the farm profit.

"Conversely, if a reduction in the quantity of cake given to an animal does not lead to a reduction of the same, or greater value, in the quantity of milk produced, profit has again been increased."

For the herds in this sample the range in margin per cow over feed costs was from £23·6–£56·5 with an average of £45·5.

*Margin per acre*

"Margin per acre is a function of the margin per cow and the number of cows per acre. Each farm which achieved a margin per acre above the average was also above average in the other two respects." It was interesting to note that a high density of stocking was such a marked feature of general good management. For, with four exceptions, all intensively stocked herds had a higher than average margin per cow and all herds with a lower than average margin per cow were not intensively stocked. In the conditions of this survey this meant that an average stocking rate of about 1¾ acres per cow instead of the prevailing two acres, would have increased profitability, especially if the change enabled the farmer to keep more cows. On the average size of farm of 48 acres, where 36 acres were devoted to the dairy herd, the increase of stocking rate from 1 cow to 2 acres to 1 cow to 1¾ acres would have enabled herd size to be increased from 17–20 cows, which in turn might reasonably be expected to have increased farm income by £200 per year. The average margin per acre over feed costs achieved by these herds was £29·4 with a range of from £13·1–£42.

The authors concluded that, although no current national figures of costs and returns were available, the average margin of milk receipts over food costs realized on these farms bore comparison with that of most other systems of milk production.

*South-West England*

Another study of feeding practices in the west of England was carried out by Langley[6], of Exeter University. Langley traced briefly the changes in the average consumption of different feeds in the South-West as shown by the National Investigation into the Economics of Milk Production. This is summarized in Table 7.

TABLE 7. *Average rates of feeding per cow in the South-West 1938–39 to 1956–57*

| | 1938–39 | 1944–45 | 1950–51 | 1956–57 |
|---|---|---|---|---|
| Concentrates | *Per cow (cwt)* | | | |
| Purchased | 16·8 | 8·4 | 12·9 | 16·3 |
| Homegrown | 3·5 | 5·3 | 2·9 | 2·7 |
| Total | 20·3 | 13·7 | 15·8 | 19·0 |
| Hay | 16·7 | 12·6 | 17·7 | 15·1 |
| Silage | 1·2 | 3.0* | 21·6 | 25·3 |
| Straw | 2·2 | 7·6 | 1·9 | 0·9 |
| Roots and greenfodder | 26·4 | 52·4 | 57·2 | 66·3 |
| Other | — | — | — | — |
| Yield per cow (gallons) | 596 | 546 | 656 | 780 |
| No. of farms in group | 61 | 60 | 64 | 62 |

* Estimated breakdown of roots and green fodder

The report then discussed the factors which influenced the dependence placed on various foods on different farms. The seasonality of production will determine to some extent the type of food fed since the availability of fodder varies. The quality of homegrown fodder may vary from farm to farm and so may the cost of its nutrient content. Where the acreage of land is limited it may benefit a farmer to obtain the greatest yield of nutrients per acre, irrespective of the cost, hence the popularity of kale. Where labour is a limiting factor, labour requirements per ton of nutrients will be of more importance and grass or silage may be preferred. Finally, especially with high yielding cows, intake of sufficient nutrients from bulk foods is usually limited by the capacity of a cow, and hence more concentrated food may have to be substituted.

A study of the pattern of bulk feeding was carried out on 60 herds over one year followed by the collection of both physical and financial records for 46 dairy herds from April 1959 to March 1960.

In the first study the frequency of bulk foods available for feeding the dairy herd was as follows:

TABLE 8. *Number of herds receiving individual foods*

| | Random sample of 60 Devon herds 1958–59 |
|---|---|
| | *No. of Herds* |
| Hay | 59 |
| Kale | 50 |
| Silage | 25 |
| Mangolds | 25 |
| Turnips and swedes | 12 |
| Cabbage | 10 |
| Straw | 6 |
| Fodder beet | 5 |
| Rape | 1 |
| Potatoes | 1 |
| Maize | 1 |

The quantity of these foods fed and their contribution to total food supply is shown in the following table.

TABLE 9. *The average winter ration per cow and the estimated contribution of individual foods to the feed supply (excluding grazing)*

| | Quantity fed per cow (cwt) | Assumed Analysis S.E. % | lb of S.E. | Per cent of total S.E. in Bulky foods % | in Bulky foods and concs. % |
|---|---|---|---|---|---|
| Hay | 21·0 | 34·0 | 692 | 47·5 | 30·3 |
| Kale | 40·8 | 9·5 | 434 | 29·8 | 19·0 |
| Silage | 14·7 | 12·6 | 207 | 14·2 | 9·0 |
| Mangolds | 7·0 | 6·8 | 53 | 3·6 | 2·3 |
| Cabbage | 3·4 | 8·0 | 30 | 2·1 | 1·3 |
| Other | 5·2 | 7·0 | 41 | 2·8 | 1·8 |
| | | | 1,457 | 100·0 | — |
| Concentrates | 11·4 | 65·0 | 830 | — | 36·3 |
| | | | 2,287 | — | 100·0 |

On the farms where silage was fed, about 35 cwt per cow was the average ration, for kale the ration allocated was between ⅕–⅓ acres per cow. The report did not list the optimum combination of bulk feeds as this would vary from farm to farm, but it did emphasize that hay, silage and kale could supply all that was required from bulky foods on many dairy farms.

The pattern of feeding concentrates is shown by the following table:

TABLE 10. *Distribution of herds by the quantity of concentrates fed per cow and per gallon (October to March)*

| Concentrates fed per cow (cwt) | No. of herds | Concentrates fed per gallon (lb) | No. of Herds |
|---|---|---|---|
| Nil | 1 | Nil | 1 |
| Under 5 cwt | 4 | Under 1 lb | 1 |
| 5 and under 10 cwt | 19 | 1 and under 2 lb | 3 |
| 10 and under 15 cwt | 23 | 2 and under 3 lb | 13 |
| 15 and under 20 cwt | 10 | 3 and under 4 lb | 18 |
| 20 and under 25 cwt | 2 | 4 and under 5 lb | 16 |
| 25 cwt and over | 1 | 5 lb and over | 8 |
| | 60 | | 60 |
| Average=11·6 cwt per cow in those herds receiving concentrates | | Average=3·7 lb per gallon in those herds receiving concentrates | |

From a study of these practices the author was able to discern broadly three different systems of feeding and hence of milk production. These systems were defined as follows:

"*a.* a *bulk-feed* or forage farming system where the herd was fed entirely or almost entirely on bulky foods receiving little or no concentrates or corn of any kind;

*b.* a *moderate* system where average yields per cow were produced on moderate levels of feeding with bulk foods together with some concentrates;

*c.* a *high-yield* system where the aim was for high yields per cow from considerable concentrate feeding in conjunction with bulk foods."

Small groups of herds who followed these systems were used as case studies and the following general conclusions were reached.

*a. Bulk feed*—this group was not well represented in the area but three farms feeding respectively, no concentrates, 2·8 cwt and 5 cwt per cow annum were studied. The advantages of this system should be 1. low feed and labour cost and 2. profits which were not markedly affected by fluctuations in the prices of milk or purchased food. The possible disadvanatage of the system was the necessity of feeding good quality bulk foods so that, with their limited intake, cows could absorb sufficient nutrients. The provision of this food may be a major management problem. There was also a danger of placing too much emphasis on low unit cost, and hence high profit per gallon at the expense of yield. "...... total profits are dependent on profit per gallon multiplied by the number of gallons produced. Hence a lower profit per gallon on more gallons may give a bigger total profit than a higher profit per gallon on a smaller yield." A third disadvantage was apparent if the acreage requirement per cow for bulk-fed herds were higher than under other systems, this might make this system unsuitable for small farms.

*b. Moderate system*, herds with average yields (700–750 gallons), at average rates of feeding (between 2 and 4 lb of concentrates per gallon) and at average density of stocking from 1·8–2·2 acres per cow. Producers claimed that this system was 'trouble free' as far as management was concerned and that expensive overfeeding was ruled out. However generally speaking "moderate practices only lead to average profits" and if some resources were underemployed there should be scope for further profit.

*c. High-yield system*, this was followed by herds with yields of over 900 gallons. Its advantages were 1. when high yielding cows were making economic use of a large amount of feed, returns would be maximized at a level higher than average; 2. overhead costs were spread over a larger number of gallons; 3. high yields offered the small (acreage) farmer a means of expanding his business; and 4. it might be possible to increase the density of stocking if less bulk feeds had to be grown.

Langley looked closely at the case studies which followed each of these systems. The table overleaf shows the financial results of the three systems and the average of the whole group. The figures for each system are the average of the herds given as being representative of the system.

The financial results of the three bulk feeding farms compared unfavourably with those of the farms on the other systems. Thus profits per cow on two of the farms and profits per acre on all three farms were lower than the average derived from the whole sample.

It appeared that the average bulk fed cow in the South-West yielded only a little over 500 gallons, and used between 2½ and 3 acres of land.

Herds with average or above average yields under the moderate system earned a margin over feed and labour costs of £40–£45 per cow. Good profits, both per cow and per gallon, were earned (£73·5, £52·7 and £63·3 per cow respectively and between £36·5–£65·6 per acre) by three out of the four high yield farms and the high-yields were obtained at average standard feeding rates (2·8–4·0 lb concentrates per gallon) and without excessive labour.

From the evidence of this study the author concluded that the high yield system was the most profitable one. However it is very doubtful if these few case studies provide enough evidence on which to choose or condemn a system of management. It can also be argued that Langley has by definition excluded from his bulk feed group those high yielding herds which feed substantial quantities of concentrates, although at a low level per gallon, combined with the full utilization of high quality forage.

TABLE 11. *1959–60 Results by different systems**

| | MANAGEMENT SYSTEM | | | |
|---|---|---|---|---|
| | Bulk feed | Moderate | High-yield | Average of 46 Devon herds |
| Size of farm (acres) | 174 | 151 | 181 | 179 |
| Herd size (cows) | 24·9 | 34·0 | 40·1 | 35·0 |
| Farm feed acres per cow | 2·6 | 1·9 | 1·9 | 1·8 |
| Concentrates per cow (cwt) | 2·9 | 17·3 | 29·2 | 19·8 |
| Yield per cow (gal) | 531 | 725 | 960 | 745 |
| Per cent winter milk | 36·1 | 45·0 | 52·7 | 48·2 |
| Hours per cow† | 114 | 86 | 100 | 92 |
| Concentrates per gal (lb) | 0·6 | 2·7 | 3·4 | 3·0 |
| | | | *Per cow* | |
| Returns (milk only) | £78·1 | £106·2 | £141·0 | £110·1 |
| Costs | | | | |
| Foods | £ | £ | £ | £ |
| Purchased | 3·0 | 19·4 | 44·0 | 25·8 |
| Homegrown | 13·6 | 18·0 | 13·9 | 16·0 |
| Grazing | 10·6 | 9·8 | 6·9 | 8·0 |
| Total foods | 27·2 | 47·2 | 64·8 | 49·8 |
| Margin (over feed costs) | 50·9 | 59·0 | 76·2 | 60·9 |
| Labour | 21·1 | 17·2 | 19·6 | 18·1 |
| Margin (over feed and labour) | 29·8 | 41·8 | 56·6 | 42·8 |
| | | *Pence per gallon* | | |
| Returns | 35·5 | 35·2 | 35·2 | 35·7 |
| Feed costs | 12·8 | 15·7 | 16·2 | 16·0 |
| Margin (over feed) | 22·7 | 19·5 | 19·0 | 19·7 |
| | | *£ per acre* | | |
| Margin (over feed) | 20·1 | 31·5 | 43·6 | 33·1 |

* Averages of herds representative of each system: Bulk feed, 3; Moderate, 4; High-yield, 4.
† Direct labour used on dairy herd, but excluding work on home grown feeds.

*Eastern Counties*

A report by Barnard and Scott[7] of Cambridge follows a similar line to that of Langley and studies different systems of milk production. Their object was to investigate two avenues by which farmers could increase their profits per cow, e.g., by increasing their receipts through higher yields or by lowering costs "which usually means feeding more fodder". To study these approaches, which correspond to the High Yield and Bulk Feed systems of production, and also that of the "Traditional" herds whose management falls between the two extremes, the authors analysed the results of 71 herds for two years.

These herds were on farms where, typical of the Eastern Counties, livestock enterprises tended to be subsidiary to the main farm plan, which is based on arable cropping. Since the results of this survey show that the income of many of the traditional herds was only 15*s*. 0*d*. per acre, it was highly relevant to study farms where the two contrasting alternative policies were practised.

The 71 herds in the sample were grouped, according to concentrate inputs and yields per cow, as follows 1. Bulk feed herds—these were defined as herds where "irrespective of yield, less than 4 lb of concentrates are fed per gallon in winter (October to March) and less than 2 lb per gallon in summer (April to September)". Eighteen such herds were included in the present sample. No bulk-feed herds had yields of over 1,000 gallons a year. 2. High yield herds—there were 23 herds in this group with yields exceeding 1,000 gallons per cow irrespective of the use of concentrates. 3. Traditional—30 herds in this sample were classified as traditional, they had yields below 1,000 gallons and fed over 4 lb per gallon in winter and 2 lb in summer. These were the herds which typified dairy management in the Eastern Counties.

*Bulk Feed Herds*

The amount of bulk foods which a cow can consume in a day limits the amount of nutrients which it can obtain from bulk feed alone. The following table shows the amount of dry matter from different foodstuffs a cow must consume to obtain sufficient nutrients for one gallon of milk.

TABLE 12. *Source of nutrient and consumption of dry matter*

| Source | Dry matter consumed in obtaining nutrients for 1 gallon |
|---|---|
| Concentrates | *lb* |
| Flaked maize | 2½ |
| Barley | 3 |
| Oats/Proprietary cakes | 3½ |
| Fodders | |
| Kale | 4 |
| Good grazing | 4½ |
| Mangolds | 4¾ |
| Silage | 5 |
| Hay | 6 |
| Oat straw | 10¾ |

Accepted standards suggest that a cow can eat 3 lb per day of dry matter for every 1 cwt of body weight, so that the consumption of an 11 cwt Friesian cow is limited to about 33 lb of dry matter per day. "Thus, if our Friesian cow is fed entirely on hay, she can consume nutrients sufficient for maintenance and 2¾ gallons before reaching the limit of her appetite. If, however, dairy cake replaces that part of the hay fed for production, she can consume nutrients sufficient for maintenance and 4¾ gallons."

TABLE 13. *The pattern of feeding on bulk fed and traditional herds for different months*

| Per cow | November |  | February |  | June |  | August |  |
|---|---|---|---|---|---|---|---|---|
|  | Bulk feed | Trad | Bulk feed | Trad | Bulk feed | Trad | Bulk feed | Trad |
| Daily yield (gal) | 2·6 | 2·5 | 2·8 | 2·8 | 2·8 | 2·8 | 2·3 | 2·4 |
| Daily ration | *lb* | *lb* | *lb* | *lb* | *lb* | *lb* | *lb* | *lb* |
| Hay | 5½ (71) | 11 (52) | 11 (74) | 11½ (52) | — | — | — | — |
| Kale | 69 | 53 | — | — | — | — | — | — |
| Silage | — | — | 81 | 43 | — | — | — | — |
| Grazing (imputed) | 30 | — | — | — | 109 (91) | 97 (81) | 114 (90) | 101 (78) |
| Concentrates | 7¾ (29) | 12½ (48) | 7¾ (26) | 13½ (48) | 2½ (9) | 5¼ (19) | 2½ (10) | 5¾ (22) |
| Dairy milk yield from fodders (gal) | ¾ | nil | 1 | nil | 2⅓ | 1¾ | 1¾ | 1 |
| Concentrates per gal (lb) | 3 | 5 | 2¾ | 4¾ | 1 | 2 | 1 | 2½ |

*Note.*—The figures in brackets ( ) are the percentage of total nutrient obtained from the different feeds.

The report suggested the following pointers to the successful organization of a bulk feeding system:

1. yield per cow would be in the region of 750–950 gallons. This covered overheads adequately and permitted good use of fodder in the production ration. This system was definitely not a low-yield system;

2. fodder would supply about four-fifths, and concentrates about a fifth, of the total nutrients. Put another way, concentrates would be fed at an average of some 2 lb a gallon—about half the rate common in practice. The system was definitely not a non-concentrates one;

3. the quality of the fodder must be good, or the system would be doomed to failure.

The bulk feeders were financially successful and obtained a high level of milk from grass and fodder crops without sacrificing milk yield. Table 13 compares their feeding practice with that of "traditional" herds at different stages in the year.

These figures emphasized the dependence of the bulk feed system on the use of grass. In summer maintenance plus 2 gallons are produced from grass, almost twice the output of the traditional herd.

By extending the grazing season and feeding good quality silage in the winter the bulk fed herds produced maintenance+1 gallon from bulk feeds against maintenance only in the traditional herds. Both systems required the same input of land, for while the bulk feeders naturally grew more fodder crops they grew less cereals. In addition the bulk feeders fed 8 cwt less than traditional herds. By using the Dairy Herd Grazing Check Sheet mentioned on page 24 the farmer can judge the efficiency of his grass and management.

TABLE 14. *Key factors*

| | Bulk feed | Traditional |
|---|---|---|
| Food cost per cow | £47 16*s*. | £62 2*s*. |
| Food cost per gal | 14*s*. 1*d*. | 18*s*. 0*d*. |
| Yield per cow | 812 gal | 829 gal |
| Acres per cow | 2·17 | 2·20 |
| Source of foods | | |
| Yield per cow from fodders | 458 gal | 226 gal |
| Yield per cow from fodders (daily) | 1·25 gal | 0·62 gal |
| Concentrates per gal | 2·26 lb | 3·97 lb. |
| Utilization of grazing | | |
| Hay equivalent per cow from grazing | 65 cwt | 52 cwt |
| Grazing supplies bulk feeders with 260 gal per cow at cost of: | £3 13*s*. Cost to traditional: | £10 10*s*. |

The table above shows that the food cost of the bulk feeders was only three-quarters of that in the traditional group because they obtained more than twice as much milk from fodders and fed only half as much concentrates per gallon. The saving in cost—£14 a cow—was nearly all extra profit, for their greater reliance on fodders led neither to significantly lower yields nor to higher acreage requirements per cow.

Grassland was the main contributor to the greater input of fodders. In particular, a combination of a longer grazing season, a more productive use of each acre and a slightly greater acreage of grazing per cow resulted in an extra 13 cwt hay equivalent per cow from this source, with a consequent saving of nearly £7.

The authors concluded: "Although Bulk Feeders may not demonstrate the ultimate limits to a better use of fodders, the fact that their relatively modest standards brought considerable financial advantage should be of interest and encouragement to traditional herdsmen. At the same time it invalidates any argument that they have some peculiar advantage not available to others."

### *High Yield Herds*

These herds used the alternative method of increasing profits by raising receipts, and so spread the overhead costs of cow-keeping over a larger gallonage. Where receipts are 3*s.* 0*d.* a gallon and the production ration costs 1*s.*, 2*s.* per gallon are left to pay for the overheads. If overheads are £50 a cow profits will increase with yield as follows:

TABLE 15. *Yield and profit of high yield herds*

| Yield | Profit |
|---|---|
| *gal* | £ |
| 500 | Nil |
| 600 | 10 |
| 700 | 20 |
| 800 | 30 |
| 900 | 40 |

However the relationship between yield and profits is not as simple as this, for three factors disturb the linear relationship 1, the capacity of the cow's stomach, 2, the cow's potential, since as yield approaches its maximum, extra food will be converted into fat, 3, as consumption of feed increases the efficiency of conversion declines. "For example, a cow's first gallon of milk might come from 7 lb of hay costing 6*d.*, her second and third each from 4 lb oats and beans costing 9*d.* and subsequent gallons from 4 lb of dairy cake costing 1*s.* 2*d.*" It is seldom appreciated, say the authors, that the law of diminishing returns, the often quoted bugbear of high yielding herds, applies equally to cows at a much lower yield if their capacity is low. A good herdsman will adjust his feeding and management system to take account of, and minimise the effect of diminishing returns. Also it may often be profitable to produce more milk and accept a lower margin per gallon, even after the point at which the rising production costs are no longer offset by falling overheads per gallon, and hence total costs are rising.

The results achieved by the 23 high yield herds in this study were compared with the results of the other groups in three important respects. Firstly the advantage gained by the greater spread of overhead costs. Secondly the comparison of costs per gallon of the production ration, and thirdly the differences in total costs. The following table compares the overhead costs per gallon for the three systems.

TABLE 16. *Overhead costs*

| | High yield | Traditional | Bulk feed |
|---|---|---|---|
| Overheads per cow | £57 18*s*. | £58 10*s*. | £45 14*s*. |
| Yields per cow | 1104 gal | 829 gal | 812 gal |
| Overheads per gal | 12·58*d*. | 16·96*d*. | 13·50*d*. |
| Difference | — | 4·38*d*. | 0·92*d*. |

There were two factors at work here which reduce overhead cost per gallon, the first was the level of total overhead costs per cow, and the second the number of gallons over which these costs are spread. The first reason accounted for the similarity between the overheads per gallon between High Yield and Bulk Feed Herds.

If, on both high yield and traditional herds, costs of production were similar at 1*s*. 4*d*. per gallon, milk at 3*s*. 0*d*. a gallon would leave a margin of 1*s*. 8*d*. per gallon to cover overhead costs. With the latter at £58 per cow, a yield of 700 gallons would be required before they are met. A comparison of high yield and traditional herds shows that the former were left with three times as much profit-bearing milk as the latter, i.e., 400 gallons as against about 130.

The advantage of increasing yields to reduce overheads in this way may be diminished by a rise in production costs. However Table 17 shows that the weight of concentrate equivalent,* when adjusted for milk quality, was almost identical. "Thus there is no more evidence of diminishing returns in the High Yield than in the other groups."

TABLE 17. *Weight of concentrate equivalent per gallon for production*

| | High yield | Traditional | Bulk feed |
|---|---|---|---|
| | *lb* | *lb* | *lb* |
| Actual weight | 5·13 | 5·44 | 5·21 |
| Adjusted to 3·7 per cent milk | 5·13 | 5·12 | 5·06 |

Although the cost of the production ration fed in the high-yielding herds was 16 per cent more than the traditional herds, and 53 per cent more than the Bulk feeders, the differences between the receipts per cow and the costs of its production ration were:

*Margin per cow*
£ *s*.
High yield 1104 gal × (36*d*.—13·34*d*.) = 104 5
Traditional 829 gal × (36*d*.—11·54*d*.) = 84 10
Bulk feed 812 gal × (36*d*.— 8·73*d*.) = 92 5

"Thus it becomes clear that costs per gallon are not necessarily any higher in high yield than in low yield groups. Although the High Yield system involves heavy expenditure per cow, it is justified by the yields obtained."

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* All feedingstuffs were converted to weight of concentrate equivalent assuming a S.E. of 62 per cent.

Comparing the profitability of the two specialist systems, the high yield and high cost herds earned a margin over feed costs greater by £14 than the bulk feed ones. However when non-food costs were taken into account the final profit per cow was about the same. The comparison is summarized in the following table.

TABLE 18. *Most profitable herds Average results 1955–57*

| | Bulk feed | | High yield | |
|---|---|---|---|---|
| | 5 High profit | All herds | 5 High profit | All herds |
| Herd size | 53 | 41 | 45 | 41 |
| Yield per cow (gal) | 916 | 812 | 1179 | 1104 |
| Concentrates per gal (lb) | 1·97 | 2·27 | 3·59 | 4·01 |
| Gallonage obtained from fodder | 555 | 458 | 330 | 246 |
| Hay equivalent from grazing cwt per cow | 77 | 65 | 68 | 57 |
| Gallons per hour of labour | 9·62 | 7·91 | 7·69 | 7·16 |
| Acres per cow (followers included) | 2·57 | 3·07 | 3·09 | 2·95 |
| Costs and returns (per gal): | *d.* | *d.* | *d.* | *d.* |
| Receipts | 36·84 | 36·85 | 37·61 | 37·37 |
| Costs | | | | |
| Foods | 9·27 | 10·84 | 13·48 | 15·65 |
| Grazing | 3·98 | 3·29 | 1·67 | 1·90 |
| Labour | 4·85 | 5·92 | 6·07 | 6·34 |
| Miscellaneous | 3·24 | 3·85 | 3·48 | 3·91 |
| Herd replacement | −0·33 | 1·27 | 0·85 | 1·13 |
| | 21·01 | 25·17 | 25·55 | 28·93 |
| Profit | 15·83 | 11·68 | 12·06 | 8·44 |
| Profit per cow | £60 8*s.* | £39 10*s.* | £59 4*s.* | £38 16*s.* |
| Profit per acre* | £23 10*s.* | £12 18*s.* | £19 4*s.* | £13 4*s.* |

* Including an allowance for young stock

Labour costs were higher for the high yield herds; the reasons for this extra cost varied but included such factors as greater use of cowsheds, longer milking times, extra care with feeding, stripping etc. But it was clearly not known how much extra attention was necessary to obtain high yields. As, however, labour productivity, in terms of gallons per labour hour, was similar in each system, much of the extra labour appeared to be justified. As for miscellaneous costs, which included extra veterinary care and depreciation of extra equipment, costs were again higher as must be expected. In view of this it could be assumed that non-food costs for high yield herds would be above those for bulk feed ones, or the two systems could alternatively be called "high cost" and "low cost". At the time of this study the two systems made the same sort of profit; however, as the high yielders sold more milk and bought more food, etc., they were especially vulnerable to changes in costs and prices. The High Yield system was "more of a gamble" than the bulk-feed one and fairly violent fluctuations in income could occur to complicate forward planning. The following table shows a wide fluctuation in profits of the high yielding herds in the three years considered.

TABLE 19. *Trends in costs and returns per cow*

| | 1955–56 | | | | 1956–57 | | | | 1959–60 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bulk feed | | High yield | | Bulk feed | | High yield | | Bulk feed | | High yield | |
| | £ | *s.* | £ | *s.* | £ | *s.* | £ | *s.* | £ | *s.* | £ | *s.* |
| Receipts | 129 | 2 | 179 | 18 | 120 | 8 | 164 | 0 | 123 | 14 | 168 | 12 |
| Food costs | 48 | 14 | 83 | 4 | 46 | 18 | 78 | 6 | 45 | 4 | 71 | 18 |
| Other costs | 38 | 0 | 52 | 0 | 36 | 14 | 52 | 10 | 39 | 4 | 56 | 4 |
| Total costs | 86 | 14 | 135 | 4 | 83 | 12 | 130 | 16 | 84 | 8 | 128 | 2 |
| Profit | 42 | 8 | 44 | 14 | 36 | 16 | 33 | 4 | 39 | 6 | 40 | 10 |

The receipts of the high yielders fell by £15 18*s.* between 1955–56 and 1956–57 compared with a drop of only £3 10*s.* for the low yielding herds of the bulk fed group. In contrast they gained three times as much as the bulk feeders from the fall in feed prices between 1955–56 and 1959–60, their feed costs falling by £11 6*s.* as against £3 10*s.* for the bulk feeders. The report concludes that "the Bulk Feed system is better suited to those who prefer the greater certainty of a fairly level profit from year to year".

Farmers following each system should beware of the *bad* features to which each system is prone. From this study it was shown that the lowest profit bulk feeding herds fed too much bulk of an inferior quality, which contributed to low yields, e.g., the average yield of the five least profitable of the farms, was below 700 gallons. On the other hand, the "high yield" farmers must beware of feeding excessively to obtain impressive but unprofitable high yields.

Finally this report considered briefly the alternatives facing the "traditional" herds who want to increase profits. The weaknesses of these herds can be diagnosed from the figures given in Table 20.

TABLE 20. *Key factors—Average results 1955–57*

| | High yield | Traditional | Bulk feed |
|---|---|---|---|
| Profit | | | |
| Per cow | £38 16*s.* | £17 4*s.* | £39 10*s.* |
| Per acre | £13 4*s.* | £5 12*s.* | £12 18*s.* |
| Acres per cow* | 2·95 | 3·07 | 3·07 |
| Costs | | | |
| Overhead costs per cow | £57 18*s.* | £58 10*s.* | £45 14*s.* |
| Overhead costs per gal | 12·58*d.* | 16·96*d.* | 13·50*d.* |
| Production costs per gal | 16·35*d.* | 16·09*d.* | 11·67*d.* |
| Total costs per gal | 28·93*d.* | 33·05*d.* | 25·17*d.* |
| Yield | | | |
| Yield per cow (gal) | 1104 | 829 | 812 |
| Foods | | | |
| Concentrates per gallon (lb) | 4·01 | 3·97 | 2·26 |
| Gallons per cow from fodder | 246 | 226 | 458 |
| Hay equivalent per cow from grazing (cwt) | 57 | 52 | 65 |
| Labour | | | |
| (Parlour herds) | | | |
| Hours per cow | 134 | 130 | 96 |
| Yield per cow (gal) | 1055 | 827 | 815 |

---

* Including an allowance for young stock.

From the table it can be seen that the weaknesses lie in the fact that the "traditional" herds combined the high overheads and production costs of the "high yielder" with the moderate yield of the "bulk feeder". It is up to the farmer to decide to either make his yield match his costs or his costs match his yields.

The report concluded "whereas traditional herdsmen have both costs and yields to consider, the bulk feeders should think mainly in terms of raising yields and the high yielders in terms of lowering costs. That the ideal of high yields with moderate costs is feasible, is demonstrated by the top ranking Bulk Feed and High Yield herds."

## GRASS

Grass has long been regarded as the cheapest feed for a dairy cow, it can also be the most profitable. However, since grass is not a readily saleable crop on its own, its profitability depends entirely on the use which is made of it, so it is not surprising to find that it has been a subject for research at several universities.

Farmers often forget that grassland and other feed crops, even when not utilized, bear a heavy share of the farm overhead costs. These "fixed costs" include rent, the wages of regular farm workers, depreciation of machinery, repairs, etc., and every acre must contribute to the covering of these fixed costs before any "profit" can be claimed. The variable costs of producing a given quantity of nutrients via grass, are usually much lower than if they obtained through purchased feeding stuffs and on most farms are far less than the cost of the purchased feeds used to supplement grass which is already largely paid for.

Any farmer wishing to look critically at his grassland management must start by measuring how much production he already gets from grazing. To measure the utilization of grass during the summer grazing season Cambridge University have designed a 'Dairy Herd Grazing Check Sheet',[9] to be kept by the farmer. A minimum of information is required, for example: gallons of milk produced, numbers of cows, purchased and homegrown concentrates fed, the acreage grazed by the dairy herd. Performance is measured against a "grazing index" which can be translated into the equivalent cost of hay. Use of this working sheet in the Eastern Counties has shown ranges in utilized yield of from one to four tons of hay equivalent per acre.

It also showed densities of stocking varying from 1 cow to ¾ acre to 1 cow to 1½ acres, i.e., the grassland management on the former farms could be reckoned to be twice as efficient. A farmer with 20 cows who doubled his stocking density in this way would free 15 acres for other use. This acreage under barley should give an increase in net income of some £300 without capital expenditure or any radical change in the farm organization.

In "Milk Production from Grazing"[10], Winter analysed the records of 30 farms in Durham, Northumberland, Cumberland and Westmorland from 1955–57, in order to discover how many gallons of milk per acre were being produced from grazing alone.

He calculated the milk output per acre grazed in the following way. The total grazing acreage was taken to be the total of:

*a.* acreage of pasture;

*b.* ⅓ of the area cut over for hay/silage where the aftermath was grazed;

*c.* acreage equivalent of supplementary foods fed to stock while grazing. He then converted all grazing stock to units of cow-grazing days and divided the total output of milk during the summer by the portion of the grazing acreage attributable to the cows alone. Using this method the following output was found.

| | 1955–56 | 1956–57 |
|---|---|---|
| Output of milk per acre (gal) | 248 | 273 |
| Number of cow grazing days per acre | 175 | 190 |

However, the range in milk output from farm to farm was from 100 gallons to over 400 gallons.

Although a study of this type can offer no hard and fast conclusions, it can draw attention to the type of management normally associated with a high output from grass.

The association between levels of milk output per acre and expenditure on fertilizers and the age of leys was well illustrated in this study. The first of these is shown in the following table.

TABLE 21. *Cost of manures: Milk output and cow-grazing days per acre*

| | *High cost group* | *Medium cost group* | *Low cost group* |
|---|---|---|---|
| Average expenditure per acre per annum on artificial manures | 52*s.* 0*d.* | 35*s.* 1*d.* | 12*s.* 0*d.* |
| Output of milk per acre (gal) | 287 | 261 | 227 |
| Cow grazing days per acre per annum | 191 | 180 | 177 |

An allowance for purchased concentrates was included in the grazing acreage. "The implication of the results is clear enough—the more manure, the higher milk output per acre and the greater grazing capacity per acre." "The extra cost of fertilizers is in each case amply covered by the value of the extra milk produced." If an extra 60 gallons can be obtained for an additional expenditure of £2 on manures, this is a better proposition than spending £2 on cake, which would buy about 119 lb producing 33 gallons.

However, to be profitable any extra grass produced by manuring must be effectively utilized. The extra grass should replace concentrates that are fed to supplement grazing. Alternatively more cows might be kept in the present herd on a smaller acreage thus freeing land for other crops. Better grass production on its own will not increase profits; it must be accompanied by other changes in management.

### *Age of Grass*

The effect of the age of grass on production is more difficult to isolate from other variations in grassland management. Two groups of farms were distinguished in this study, those with under 29 per cent of their grassland under six years had an average output of 203 gallons per acre, whereas those with 58 per cent of the grassland under this age had an average output of 304 gallons per acre. The associations between the age of leys, expenditure on manures, and milk output per acre are shown in Table 22.

TABLE 22. *Age of leys and expenditure on manures: milk output per acre*

| | 18 farms with average expenditure on manures over 32*s.* per annum | | 12 farms with average expenditure on manures under 32*s.* per annum | |
|---|---|---|---|---|
| | 9 farms with highest av. % young grass | 9 farms with lowest av. % young grass | 6 farms with highest av. % young grass | 6 farms with lowest av. % young grass |
| | *Group 1* | *Group 2* | *Group 3* | *Group 4* |
| Average cost of manures per acre | 44*s.* 3*d.* | 49*s.* 6*d.* | 13*s.* 3*d.* | 16*s.* 1*d.* |
| Average % of grassland under 6 years old | 66·1% | 39·9% | 44·9% | 16·9% |
| Output of milk per acre (gallons) | 294 | 266 | 252 | 198 |
| Number of cow grazing days per acre | 189 | 185 | 178 | 175 |

"These results not only provide further confirmation of the economic advantages of adequate manuring which was illustrated in Table 21, but also show that the most profitable yields per acre were obtained where (comparatively) high expenditure on manures was combined with a high proportion of young grass." Thus although "the average total grazing costs per acre in Group 1 were in fact 69*s.* more than in Group 4, the extra cost was amply covered by the value of the 96 gallons of extra output."

Another point of interest was that most of the farms with the highest output per acre grazed both sheep and cattle.

### *Utilized Starch Equivalent from Grazing*

A second method of comparing output from grazing, and the use made of it, is the measurement of Utilized Starch Equivalent. This is calculated by estimating the amount of starch equivalent needed for maintenance and production by the cows grazed and relating this figure to the acreage of grazing. On this basis the average U.S.E. of the thirty Northern farms in this survey was 12·5 cwt per acre, but there was a wide range around the average, from under 8 to over 20 cwt per acre. An investigation in 1953 and 1954 showed the average total output of S.E. from grassland to be 20–21 cwt per acre, including hay and silage.

This neglect of grassland is emphasized by the figures in Table 23 which show that grazing is easily the cheapest source of S.E. available on the farm. The figures are derived from the Milk Costs Investigation, 1955 and 1956, in which these thirty Northern farms were included.

At an average rate of stocking to 1·17 acres per cow a production of 17 cwt S.E. per acre is necessary to enable a cow to obtain all its requirements for maintenance and to produce an average output of 398 gallons during the grazing period. This level of production was actually achieved on some farms and could doubtless be achieved on other, in which case (theoretically) no supplementary feeding of concentrates whatsoever should be necessary.

TABLE 23. *Estimated cost of starch equivalent for fodder crops and dairy cake*
*Average of 2 years, 1955 and 1956*

| Food | Yield per acre | Cost per ton | | Cost per ton of S.E. | |
|---|---|---|---|---|---|
| | *Tons* | £ | *s.* | £ | *s.* |
| Grazing | — | — | | 9 | 18 |
| Grass silage | 4·4 | 2 | 8 | 20 | 0 |
| Hay | 1·5 | 6 | 4 | 20 | 13 |
| Oats | 1·3 | 11 | 18 | 19 | 16 |
| Kale, cut | 18·8 | 2 | 9 | 27 | 4 |
| Kale, grazed | 17·4 | 1 | 8 | 15 | 11 |
| Swedes and turnips | 17·2 | 2 | 9 | 35 | 0 |
| Mangolds | 15·1 | 2 | 16 | 37 | 7 |
| Dairy cake @ £32 per ton (65% S.E.) | — | — | | 49 | 5 |
| Dairy cake @ £34 per ton (65% S.E.) | — | — | | 52 | 6 |
| Dairy cake @ £36 per ton (65% S.E.) | — | — | | 55 | 8 |

### *Yield of Grassland in relation to the Elevations of the Farms*

As part of his study of various factors affecting profits from milk production, Wynne, of Leeds University, has analysed the output of starch equivalent from grazing land on upland dairy farms in Yorkshire. One of his aims was to try to separate the effects of natural conditions from the effects of those factors within the control of the farmer (such as reseeding and fertilizer application). The analysis showed a strong correlation between the height of the farms above sea level and the output of starch equivalent per acre, and a much weaker relationship between costs and output. The inter-relationship between elevation, output of S.E. per acre and cost is shown in Table 24.

TABLE 24. *Heights of farms and output of starch equivalent per acre*

| Height of farm above sea level | *Costs per acre of land grazed | | |
|---|---|---|---|
| | £2 | £4 | £6 |
| | *Yields of starch equivalent in cwt* | | |
| 400 feet | 13·2 | 14·1 | 14·9 |
| 600 feet | 11·7 | 12·6 | 13·4 |
| 800 feet | 10·2 | 11·1 | 11·9 |
| 1000 feet | 8·7 | 9·6 | 10·4 |
| 1100 feet | 7·9 | 8·8 | 9·6 |

* Costs include rent, artificials and reseeding costs only.

Wynne emphasized the considerable disabilities of the upland dairy farm with their low output, short grazing season and high cost of improvements. He reported that the low correlation between yields and costs provided an explanation of the slowness of these farmers to spend much money on reseeding and artificials, for there was no guarantee that such expenditure would be profitable under their conditions.

*Rate of Stocking*

The rate of stocking has a major effect on the output of pasture as measured in U.S.E. per acre. Holmes and Sykes[12] found that U.S.E. increased from 8·1 cwt per acre, when the stocking rate was 1·76 acres pasture per cow, to 14·5 cwt when there were only 0·88 acres per cow. The use of concentrates was greater with the higher stocking rate, at 9·2 cwt per acre as against 7·7 cwt at the lower rate. However the stocking rate did not appear to influence yield or margin per cow, although margins per acre increased with a higher rate of stocking.

The interactions of utilized starch equivalent, with quantity of milk per acre of grass, with rate of stocking and with profitability of milk production during the summer grazing season, are clearly demonstrated in the following table taken from an article by Barnard[13].

TABLE 25. *The influence of grazing productivity**

| Yield group (cwt starch equivalent per acre of grazing) | Up to 7·5 | 7·5—10·0 | 10·0—12·5 | 12·5—15·0 | 15·0 and over |
|---|---|---|---|---|---|
| Average yield of starch equivalent per acre (cwt) | 5·76 | 8·66 | 11·17 | 13·61 | 18·63 |
| Quantity of milk provided by an acre of grazing (gal) | 113 | 162 | 216 | 258 | 360 |
| I. COST | | | | | |
| Per acre of grazing | £3 8*s.* | £4 2*s.* | £4 14*s.* | £5 2*s.* | £5 10*s.* |
| Per cwt of starch equivalent | 11*s.* 10*d.* | 9*s.* 6*d.* | 8*s.* 5*d.* | 7*s.* 6*d.* | 5*s.* 11*d.* |
| Per gal of milk | 7·22*d.* | 6·07*d.* | 5·22*d.* | 4·74*d.* | 3·67*d.* |
| II. FEED SUBSTITUTION | | | | | |
| Yield per cow in summer (gal) | 390 | 367 | 379 | 374 | 389 |
| Acres grazed per cow | 1·54 | 1·32 | 1·15 | 0·95 | 0·76 |
| Gallons per cow in summer from: | | | | | |
| Grazing | 174 | 214 | 248 | 245 | 274 |
| Other foods | 216 | 153 | 131 | 129 | 115 |
| Cost per cow in summer of | £ *s.* | £ *s.* | £ *s.* | £ *s.* | £ *s.* |
| Grazing | 5 5 | 5 8 | 5 8 | 4 17 | 4 4 |
| Other foods | 20 14 | 14 13 | 12 11 | 12 7 | 11 0 |
| Total | 25 19 | 20 1 | 17 19 | 17 4 | 15 4 |
| III. MARGIN PER ACRE OF GRAZING | £ *s.* | £ *s.* | £ *s.* | £ *s.* | £ *s.* |
| Receipts per cow in summer | 43 18 | 41 6 | 42 13 | 42 2 | 43 15 |
| Receipts per acre | 28 10 | 31 6 | 37 2 | 44 6 | 57 11 |
| Grazing and other food cost per acre | 16 17 | 15 4 | 15 12 | 18 2 | 20 0 |
| Margin per acre | 11 13 | 16 2 | 21 10 | 26 4 | 37 11 |

* From a five-year study of grazing use in the period 1948–52, and based on the utilized yield of starch equivalent per acre as being a suitable measure of both production and utilization of grazing.

*Effect of Concentrate Feeding on Productivity of Grassland*

A study by Holmes and Sykes[12] of 364 herds co-operating in the National

Investigation into the Economics of Milk Production, suggested that "there was a reduction in U.S.E. with increasing level of concentrate feeding of the order of 3 cwt U.S.E. per acre, for 7 cwt concentrates fed per cow." There was however a small increase in U.S.E. with increasing yield per cow and this was probably due to a higher efficiency of food conversion.

The authors reached the conclusion that "so long as enough good quality grazing is available no worthwhile increase in milk yield or milk composition can be obtained from the feeding of supplementary concentrates." There are three exceptions to this dictum:

*a.* if winter feeding normally continues into April;

*b.* concentrates may be the means of providing Magnesium Oxide;

*c.* to "steam-up" autumn calves.

Only 2 of the 30 herds in a Northern survey[10] fed no concentrates in the grazing period. The amounts fed averaged 6·8 cwt per cow in the year 1955–56 and 5·9 cwt in 1956–57.

The monthly distribution was as follows:

TABLE 26. *Concentrates fed per gallon each month during the grazing period*
*Average of 30 farms*

| Month | 1955–56 | 1956–57 |
|---|---|---|
| | *lb* | *lb* |
| October | 3·31 | 2·68 |
| November | 3·58 | 2·94 |
| April | 2·73 | 1·85 |
| May | 1·42 | 1·26 |
| June | 1·49 | 1·19 |
| July | 1·60 | 1·29 |
| August | 2·18 | 1·47 |
| September | 2·46 | 2·07 |
| Grazing period | 1·98 | 1·60 |

The Northern farmers gave the following reasons for feeding concentrates during this period; 1, to facilitate the tying upof cows and to encourage the let-down of milk; 2, to prevent disorders (grass tetany, scour, etc.); 3, to supplement the quantity or quality of the grass; 4, to steam up in-calf cows and heifers; 5, to help high-yielders. The farmers who fed concentrates to supplement the quantity and quality of the grass might have been better advised to use more fertilizer to improve it. "In Table 21 the high cost manure group (52*s*. per acre) showed an output of milk per acre of 287 gallons, 60 gallons in excess of the low cost manure group (12*s*. per acre)."

In their study of feeding Holmes and Sykes found that the response to supplementary concentrate feeding was small in terms of milk yield and composition, and it may have led to a reduction in the amount of grass consumed.

However an analysis of the National Milk Records showed supplementary concentrates were fed to over 90 per cent of the dairy herds even in May and June when grass production was at a maximum. Experiments showed that 1 lb of supplementary concentrates increased milk yields by an average of

0·3 lb milk and in no case by more than 1 lb. With milk at 3*s*. a gallon and concentrates at 3*d*. to 3½*d*. per lb, it was impossible to escape the conclusion that such feeding was not economic.

Supplementary feeding early in the lactation, may alter the shape of the lactation curve, and lead to higher total milk yields, or it may be fed to supply minerals or when good quality grazing is not available. However, bearing in mind the relationship between concentrate input and milk output during the summer period, much scope remains for reducing concentrate usuage.

### *Financial results*

The following results (Winter[10]) refer to thirty northern dairy farmers in years 1955–56 and 1956–57. "The results emphasize the value of growing grass as a cheap milk producer. Although the pool prices were lowest during the months when the cows were on grass, taking the farms as a whole, the margin between costs and returns was quite substantial. There was, as usual, a wide range in margins between farms and on many the margin could have been improved by better pasture management and a curtailment in the use of supplementary food. The average net cost for purchased foods per cow over the two grazing periods was £8 representing 47 per cent of the total net food costs. For home-grown supplementary foods the respective figures were £1·7 and 9·7 per cent. Grazing cost £7·2 per cow and accounted for only 43·3 per cent of the total food costs. Nevertheless, grass supplied 75 per cent of the estimated starch equivalent required for maintenance and production.

"The average cost during the grazing season was 18·8*d*. per gallon. This was slightly below the average price of about 19*d*. received during these years for milk diverted to the manufacturing market. A surplus over liquid requirements, therefore, during the grazing period, just covered the cost of production."

The relationship of milk output per acre and milk production costs when the cows were at grass, is shown in Table 27.

"Although the grazing period was longer in the high output groups both the acreage of grazing per cow and the total feed acres per cow were considerably lower. This suggests denser stocking, which accounts for the high output per acre. The high yield of milk was reflected in the costs per gallon, which were appreciably lower than in the low output groups. The margins therefore were substantially greater in the high output groups."

### *A Criticism of Grassland Analysis*

The Grassland Utilisation Committee in their report[14] published in 1958, attempted to study the varying profits earned by farmers utilizing their grassland to different degrees. The report included an analysis of National Milk Cost Investigation farms for 1955–56 and 1956—57 which showed that the higher the level of utilized starch equivalent per acre the higher the margin per acre used for dairying. The report emphasized that, in their analysis, the higher profits were associated with the better production and utilization of fodder crop rather than with higher production only. In an article Wynne[15] endeavoured to make a constructive criticism of this particular analysis.

He studied the records of 48 Yorkshire farms included in the 1956–57 sample, and made the point that in this comparison of the intensity of S.E. production per acre, the farms in the low S.E. group were of a different type from those in the medium and high groups. Included in the low S.E. group were 19 (18 per cent of the group) Yorkshire farms and 16 of these were upland ones at 400 feet or more above sea level, suffering all the disadvantages of dairy farms at this altitude. Wynne suggested that, for Yorkshire at least, this analysis only proved that low S.E. productivity was associated with both upland farms and low profits, and that therefore there is no evidence to show that these farms should grow grass more intensively. However, the comparison between medium and high S.E. groups did not appear to be invalidated, although it was apparent from the Yorkshire analysis that the higher profits associated with higher S.E. production were also associated with higher yields per cow and with greater intensity of land use.

TABLE 27. *Production costs, returns and margins, etc., during the grazing period. A comparison between Groups of Farms with high and low outputs of milk per acre*

| | 1955–56 | | 1956–57 | |
|---|---|---|---|---|
| | Average of 10 farms with highest output per acre | Average of 10 farms with lowest output per acre | Average of 10 farms with highest output per acre | Average of 10 farms with lowest output per acre |
| Length of grazing period—days | 193 | 165 | 202 | 189 |
| Herd size | 42·0 | 17·9 | 38·1 | 20·0 |
| Yield per cow (gal) | 431 | 278 | 460 | 376 |
| Yield per cow per day | 2·23 | 1·68 | 2·28 | 1·99 |
| Output of milk per acre | 312 | 172 | 332 | 215 |
| Acreage of grazing per cow | 0·98 | 1·35 | 1·07 | 1·38 |
| Acreage allowed per cow for supplementary foods | 0·44 | 0·27 | 0·31 | 0·37 |
| | *Costs per cow* | | | |
| | £ | £ | £ | £ |
| Purchased feeds | 10·0 | 5·1 | 6·4 | 8·5 |
| Home-grown feeds | 2·1 | 1·5 | 2·0 | 1·6 |
| Grazing | 7·3 | 6·9 | 7·5 | 6·9 |
| Total | 19·4 | 13·5 | 15·9 | 17·0 |
| Manurial residues | 0·4 | 0·3 | 0·3 | 0·3 |
| Net cost all foods | 19·0 | 13·2 | 15·6 | 16·7 |
| Total labour | 7·4 | 6·4 | 8·0 | 7·4 |
| Miscellaneous expenses | 5·9 | 5·1 | 6·2 | 6·7 |
| Herd replacement | 0·7 | 0·3 | 1·6 | 2·2 |
| NET FARM COSTS | 33·0 | 25·0 | 31·4 | 33·0 |
| RETURNS FOR ALL MILK | 62·1 | 38·2 | 63·6 | 49·1 |
| MARGIN | 29·1 | 13·2 | 32·2 | 16·1 |
| | *Costs per gallon* | | | |
| | d. | d. | d. | d. |
| Net farm costs | 18·39 | 21·65 | 16·38 | 21·08 |
| Returns for all milk | 34·61 | 33·02 | 33·19 | 31·36 |
| MARGIN | 16·22 | 11·37 | 16·81 | 10·28 |

The Committee also attempted to answer the question whether it would pay the average farmer, who had improved the productivity of his grassland, to keep more cows or to replace concentrates by grass. In order to do this, the 3 S.E. groups were sub-divided according to their usage of concentrates per acre of land used for dairying. This analysis showed that higher profits at each level of S.E. production were made when the feeding of concentrates was high. Wynne suggested that, using this method of sub-division, there would be a strong tendency for herds with genetically high yielding cows to fall into the high concentrate sub-group, and low yielding herds to fall into the low. Because of the association between yields and profits it followed that there appeared to be a relationship between concentrate feeding and profit which was not justified by the analysis.

Wynne used an alternative method of analysis and first divided those Yorkshire farms with medium and high S.E. production per acre according to the S.E. from grass utilized in the production ration and then sub-divided these groups according to yields. His figures are shown in Table 28. From the analysis of this small sample it can be seen that, between herds of similar yields, the more profitable were those obtaining a greater proportion of the production ration from grass products. The highest profits were derived from the herds with both a high yield and a high production and utilization of grass products and kale. This conclusion led Wynne to disagree with the Caine committee's statement that "it pays, at present, to use the increased production of grass and fodder crops to enlarge the dairy herd even though it entails heavier purchases of concentrated food".

TABLE 28. *Profits and the use of forage crops at different milk yields*
*(Farms with medium or high production of S.E. per acre)*

| S.E. utilized above maintenance requirements from grassland, etc.* | Less than 4 cwt S.E. per cow | | More than 4 cwt S.E. per cow | |
|---|---|---|---|---|
| Milk yield group | Less than 825 gal per cow | More than 825 gal per cow | Less than 825 gal per cow | More than 825 gal per cow |
| Number of herds | 7 | 7 | 7 | 8 |
| Average weight of S.E. produced per acre of grassland, etc.* | 14·7 cwt | 15·9 cwt | 17·3 cwt | 17·0 cwt |
| Average weight of S.E. utilized per cow above maintenance requirements from grassland, etc.* | 0·9 cwt | 0·8 cwt | 8·6 cwt | 11·5 cwt |
| Total acreage used per cow | 1·68 acres | 1·75 acres | 2·01 acres | 2·36 acres |
| Average yield per cow | 715 gal | 934 gal | 690 gal | 996 gal |
| Average margin per cow | £16·7 | £23·3 | £26·9 | £49·9 |
| Average margin per acre | £9·9 | £13·3 | £13·4 | £21·2 |
| Concentrates fed per cow† | 19·4 cwt | 31·3 cwt | 13·3 cwt | 19·2 cwt |

* Grassland includes arable silage and kale.

† The figures originally published have been revised.

# II. Seasonality of Milk Production

## WINTER OR SUMMER MILK?

One of the objectives of the Milk Marketing Board is to minimize the amount of high priced winter milk which goes for manufacturing purposes. Ideally the Board would like to see sufficient winter production to meet the requirements of the liquid market only.

Thus the Board, despite recognizing that winter costs of production are higher, have been whittling away the differential between winter and summer milk prices.

The alternatives of winter and summer milk production have been of interest to economists in the S.W. and Beynon and Langley[16] have considered them in press articles from time to time. The important factors which determine the most profitable seasonal pattern of milk production for the individual farm remain the same from year to year. These are yield per cow, seasonal milk prices, supplies of home-grown bulk feed, density of stocking and cost of purchased food. Beynon and Langley calculated that at 1955 milk prices and with dairy cake at £35 per ton, a herd of 20 October calvers earned an extra margin of £117 over an April calving herd. A repetition of the exercise in 1958 showed that the differential between winter and summer prices had narrowed by 3*d.* per gallon and that over the average lactation the price advantage of the October calvers was only 4·2*d.* per gallon as against 5·7*d.* in 1955–56. By 1960 the position of winter milk producers had weakened further, while the provisional prices for 1960–61 showed a further fall of ½*d.* per gallon in the differential. Since the M.M.B. can influence seasonal patterns through the monthly pool prices, farmers are again questioning whether there is any advantage to winter-milk production.

The table overleaf, which shows the relative extra value earned by an autumn calving herd in different price situations, was based on the following three assumptions. Firstly, that maintenance and up to 3 gallons was obtained from grass at the peak of the grazing season. Secondly, for winter production, *a.* that 4 lb of dairy cake were fed per gallon where silage or kale were not available; *b.* when silage was available it provided maintenance and one gallon, with cake at 4 lb per gallon fed after this point; *c.* where both silage and kale were fed they were assumed to provide maintenance and one and a half gallons from October to December and maintenance and one gallon from January to March. The yields of the April calvers were reckoned to be between 20–30 gallons per head less than those of the October calvers.

The authors considered that some fairly definite guides to future policy emerged from this analysis. Those herds which produced milk partly from cheap bulk foods should continue to produce winter milk even if the price differential was further reduced. Herds with below average yields which were fed 4 lb of concentrates for every gallon were getting no marked advantage from producing winter milk and should watch future price trends carefully. Whilst those herds which were fed over 4 lb of concentrates per gallon should switch over to summer milk as quickly as possible; by doing so they would benefit both themselves and the nation.

TABLE 29. *Extra margin earned by 20 October calvers over 20 April calvers*

| Yield per cow/crops grown | With 1955 milk prices and dairy cake @ £35 per ton | With 1958–59 milk prices and dairy cake @ £32 per ton | With 1959–60 milk prices and dairy caked @ £32 per ton |
|---|---|---|---|
| | £ | £ | £ |
| 700–680 gal per cow | | | |
| (*a*) No silage or kale | 117 | 33 | 32 |
| (*b*) Silage | 287 | 185 | 185 |
| (*c*) Silage and kale | 338 | 232 | 232 |
| 850–826 gal per cow | | | |
| (*a*) No silage or kale | 232 | 127 | 124 |
| (*b*) Silage | 393 | 263 | 260 |
| (*c*) Silage and kale | 444 | 310 | 307 |
| 1000–970 | | | |
| (*a*) No silage or kale | 357 | 221 | 217 |
| (*b*) Silage | 485 | 337 | 334 |
| (*c*) Silage and kale | 536 | 384 | 381 |

# III. Herd Replacements

## *To Rear or not to Rear*

REARING or buying replacements? This decision can have a marked effect on the output and the net income of many small farmers. Two reports from Durham University[17 and 18] describe the motives for, and discuss the implications of, the decisions made.

587 milk producers in the Northern counties returned a questionnaire on this subject. The average size of farms in this sample was about 100 acres, (milk was the chief sale product) and the average herd contained 17 cows and an equal number of followers. 38 per cent of the herds were of mixed breeds while 27 per cent were pure Shorthorns and 16 per cent pure Friesians. A.I. was used in 61 per cent of the herds. A dairy bull was used on 67 per cent of herds, a beef bull on 9 per cent, while in the remaining herds the best cows were served by a dairy bull, the other cows and maiden heifers were put to a beef bull.

The sample was divided into four groups according to replacement policy as follows:

A 281 farms with their replacements entirely home-reared;
B 218 farms with most of their replacements home-reared;
C 46 farms with most of their replacements purchased;
D 42 farms with all their replacements purchased.

Thus 499 farmers out of 587 or 85 per cent chose to rear all, or nearly all, their herd replacements. It is interesting to note that these farms were, on average, only a little bigger than those who bought replacements. Also, neither the number of cows per farm nor the overall density of stocking was much increased by buying in all or most dairy replacements.

The grouping used was, however, somewhat arbitrary, for instance in Group A, some herds reared all heifers, thus enabling the farmers to be highly selective for the dairy herd, and the culling of cows as 3rd or 4th calves was fairly intensive. The author pointed out that this method always showed a profit on herd replacement where cows were usually sold in milk for good prices, but it might be offset by lower milk production in herds with a high proportion of heifers. On the other hand, some farms were rearing only enough heifers to replace natural wastage from the herd. Half the farms in Group A reared only heifer calves, the remainder reared some bull calves in addition. Of the 42 farms in Group D, 28 sold all their calves at birth while 14 reared some of the calves as beef stores.

The farmers who reared all or most of their replacements were asked to give their reasons for doing so and the following replies emerged:

TABLE 30. *Farmers' reasons for perferring to rear own herd replacements*

| | No. farmers stating reason |
|---|---|
| 1. To avoid risk of introducing disease | 323 |
| 2. To have replacements on hand when required | 311 |
| 3. To up-grade herd | 279 |
| 4. To obtain replacements cheaply | 238 |
| 5. Because home-reared stock become acclimatized and thrive better | 14 |
| 6. Because personally interested in rearing | 9 |
| 7. To utilize rough grass unsuitable for cows | 6 |
| 8. To use buildings suitable for young stock but not for cows | 1 |

Although 100 per cent of the cattle in Cumberland and Westmorland and 75 per cent and 54 per cent respectively in Durham and Northumberland were attested, the overwhelming importance in farmers' minds of the prevention of disease was not surprising when one thinks of the shattering loss which abortion, sterility or Johne's disease could lead to in a small herd. It was also not surprising that farmers should be trying to upgrade their herds through judicious home breeding from lines with a good milking record. However, as the authors comment, "this policy would not preclude purchase as an alternative method of herd improvement". The large number of farmers who gave the availability of replacements as a reason were likely to be concerned with the need to find £100 in ready cash to buy replacements if or when required urgently.

The conviction that rearing provided cheaper replacements was widespread. This was no doubt the case for the majority of farmers, although the margin was much less than many of them believed, and if opportunity costs had been taken into account the reverse may have been true. For example, to rear a heifer from birth to calving took from 2–3 years and required from 3–5 acres of land as well as other resources, and there was usually some alternative use for these resources which would have earned more income than the value of the down-calving heifer which the farmer would have had to buy if he had given up rearing.

### *Alternatives to Rearing*

When asked to what alternative use they could put the resources devoted to rearing, the farmers gave the following replies:

TABLE 31. *Alternatives to rearing in order of preference*

| Alternatives | Order of preference | | | | | |
|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th | 6th |
| 1. Keeping more cows | 300 | 81 | 23 | 13 | 2 | — |
| 2. Growing more fodder crops | 53 | 129 | 81 | 20 | 13 | 2 |
| 3. Growing more sale crops | 17 | 24 | 46 | 43 | 10 | 23 |
| 4. Keeping more sheep | 149 | 142 | 68 | 17 | 3 | 1 |
| 5. Keeping more pigs | 2 | 10 | 32 | 18 | 18 | 13 |
| 6. Keeping more poultry | 4 | 20 | 47 | 42 | 19 | 8 |
| 7. Keeping cattle for stores or beef | 12 | 7 | 1 | — | — | — |

The direct alternative of substituting cows for followers was by far the most popular possibility. No less than 419 farms considered keeping more cows as an alternative. On many upland farms more sheep would have been kept and a number of farmers would have grown more fodder crops. Comparatively few farmers considered the possibility of growing sale crops, which offer the greatest potential for profit, but it may have been that equipment was not available or not adequate to deal with any extra acreage.

The farmers who bought their replacements gave the following reasons for doing so:

TABLE 32. *Reasons for purchasing replacements*

| | No. of farmers giving reasons |
|---|---|
| 1. More cows can be kept | 46 |
| 2. Rearing accommodation inadequate | 43 |
| 3. It was considered cheaper to buy than to rear replacements | 39 |
| 4. Resources used for rearing can be employed more profitably | 39 |
| 5. One can select the type required | 4 |
| 6. Animals can be bought just when needed | 1 |
| 7. It is more profitable to sell heifers as beef or stores | 7 |

To some extent these reasons were the obverse of those given by farmers who did rear, thus some of the non-rearers thought it was cheaper to buy than rear, others that they could buy the type of animal needed with more certainty than if they tried to breed. However, the most frequent reason given was that more cows could be kept or the resources used more profitably in other ways, or that the housing required for rearing was not adequate.

In addition to this postal survey of northern milk producers described above, a more detailed study of the replacement policies of 61 of them was carried out. These 61 farms were all between 25 and 65 acres, and about one-half of them was making a reasonable income from their holdings. The average size of dairy herd was 14·5, with a range from 7·3–26·0 cows. Fifty-two of the farmers reared some dairy calves, and 38 kept other cattle. Most of the farms had poultry flocks but only one-third kept pigs, and only 16 kept sheep.

Ayrshires were the most popular breed. On 17 farms herds were maintained wholly by home bred heifers, 9 farmers purchased all their replacements and 35 farms both reared and bought in. The farms surveyed were mainly under grass; 22 were all grass. The production of fodder crops was usually the only tillage and the acreage of cash crops was negligible. The grassland management of the farms was extensive, strip-grazing was practised on less than half the farms and silage was made on only 11 farms.

*Advantages of intensity of stocking*

A comparison between 9 farms with the lowest and the 9 highest acreage requirements per cow presented this picture:

TABLE 33. *Comparison of stocking density and milk output per acre*

| | Average of 9 farms with low acreage requirements per cow (i.e. high stocking rate) | Average of 9 farms with high acreage requirements per cow (i.e. low stocking rate) |
|---|---|---|
| Acreage requirement per cow | 2·19 | 3·54 |
| Milk output per cow (gal) | 668 | 798 |
| Milk output per feed acre (gal) | 305 | 225 |

"Milk receipts per cow were appreciably higher on the low rate of stocking farms, but food costs were also much greater, so that there was little difference between the two groups of farms in the margin per cow of receipts over total cost. Per acre, however, the margin was £14 4*s.* on the farms with the low acreage requirements against £8 12*s.* on the high acreage requirement farms.

"The range in output per acre of grazing only was even wider; from 119 to 442 gallons. Since all these farms were largely dependent on grass, these figures again underline the importance of intensive grassland management, in particular of more generous manuring and stricter control over stocking."

On the 16 farms where all the pasture was strip grazed, the average output per acre of grassland was 307 gallons compared with the figure of 237 gallons on the 36 farms on which the pastures were managed extensively. This difference of 70 gallons, worth between £8 and £9, would amply compensate for the extra expenditure on manures, labour, and so on, for in fact, the average cost of grazing was only £3 16*s.* per acre higher on the strip-grazed farms.

About 30 per cent of the milking herd over the whole sample were replaced during the year, just over two-fifths of the replacements were bought at an average price of £76 16*s.*, the remainder were home reared at an average cost of £60 16*s.* per head. Good prices were realised when cows in milk were sold, these formed 36 per cent of the outgoing cows, and they realised an average price of £74 18*s.* An average price of £48 10*s.* was realized for fat, barren or diseased cows. These figures were comparatively high and resulted in 13 farms making a profit on herd maintenance.

*Comparison of Farms Rearing and Buying Replacements*

The following table gives some details of the organization of the dairy herds on the farms which reared and farms which bought in replacements.

TABLE 34. *Some comparative features of herds maintained by purchase and rearing*

| | Replacements purchased | Replacements reared |
|---|---|---|
| No. herds averaged | 9 | 17 |
| No. of cows in herd | 14·7 | 15·5 |
| No. of followers | — | 14·2 |
| Percentage of herd replaced in year | 30·5 | 28 |
| Years of herd life | 3·3 | 3·6 |
| Percentage of outgoing cows sold in milk | 25·6 | 46·6 |
| Costs of home reared replacements | — | £62 6*s.* |
| Price of purchased replacements | £81 4*s.* | — |
| Price of cows sold | £54 18*s.* | £60 15*s.* |
| No. of calves born | 10 | 16 |
| No. of calves retained for replacement | — | 4·4 |
| Price of calves sold | £10 8*s.* | £11 6*s.* |
| Value of calves retained for beef | £11 0*s.* | £11 8*s.* |

"One of the main reasons for buying replacements was that more cows could be kept. It is surprising therefore, that, despite the farms in each group averaging the same acreage, herds were slightly larger on the farms which reared their own replacements. The most probable explanation is that buildings were the limiting factor, so that replacements would have had to be reared in buildings at present housing cows. The evidence of Tables 31 and 32 is that, on the replacement buying farms, resources other than buildings, which would have been used for rearing, were diverted to grow more crops, mainly fodder, and to keep more pigs and poultry.

"The herds in the replacement purchasing group had a somewhat higher rate of replacement than those maintained by home-rearing, but even more noteworthy was the far lower proportion of outgoing cows sold in milk by the former group. This was because the cows entering the herds for which replacements were bought were somewhat older than the heifers calving into the other herds. Despite this, the purchased cows cost on average £19 more than the home reared calving heifers. Thus, the higher rate of replacement and lower prices realized for outgoing cows lead to much higher herd depreciation in the replacement buying herds. In these herds the difference between average prices for outgoing and incoming cows was £26 6*s.* against only £1 10*s.* in the other herds.

"When nearly all replacements are bought newly calved and the rate of replacement is high, less calves will inevitably be born." Further, the value of the beef calves born on each type of farm was similar, so that, even excluding the value of dairy calves to be reared, the income from calves was greater on the rearing farms. "This income", the report stresses, "from beef calves made an important contribution to lowering net costs of milk production on these small dairy farms".

As well as having higher stocking rates, which may or may not have been connected with the method of herd replacement, the self-maintained herds had higher yields per cow, 714 gallons as against the 691 gallons of the purchased replacement herds. The home rearers usually claimed that their method enabled them to up-grade their herds in the cheapest way, and the widespread use of A.I. would have helped them to achieve this. Conversely, many of the cows bought into the other group of herds were not always of good quality because of shortage of capital.

The advantages of rearing all replacements as practised on these farms can be summed up in the low depreciation rate of heifers when reared cheaply, compared with the high cash outlay required for replacements purchased in the market. Up-grading a herd is possible by selective breeding and culling and by judicious use of A.I. As against this, the economic justification for a policy of buying replacements depends on the scope for more profitable use of the land, labour and capital devoted to rearing.

### *Alternative use of rearing resources*

Under the assumption given, the following budget might be made for a farmer who was considering changing to a policy of buying replacements.

Assumptions—*i.* rate of stocking with cows the same as on farms which rear replacements;
*ii.* similar milk yields;
*iii.* similar selling price received;
*iv.* cows are bought in at the same average price as was paid by the 9 buying herds in the sample.

*Budgeted effect of buying replacements and keeping extra cows instead of followers**

| EXTRA COSTS | £ | COSTS SAVED | £ |
|---|---|---|---|
| Concentrates for 8 cows 14¾ cwt per cow @ 32*s.* 6*d.* | 192 | Concentrate for calves | 37 |
| 7 replacements (30%) @ £81 4*s.* | 568 | | |
| | | EXTRA REVENUE | |
| Extra miscellaneous | 100 | 714 gal @ 36·11*d.* per gal per cow from 8 cows | 859 |
| | | Milk fed to calves now sold | 23 |
| | | 13 extra calves sold @ £12 6*s.* | 160 |
| | | 2 extra cows culled @ £60 15*s.* | 122 |
| | 860 | | |
| Extra profit (family income) | 341 | | |
| | £1,201 | | £1,201 |

* Based on table by Winter, page 18.[18]

As a result of this change family income would increase by £341 or 40 per cent. If new standings had to be provided the profit might be reduced by nearly £100 per herd.

The author pointed out that, although the profit from most dairy herds would be raised by replacing followers with cows, the extra profit may not be sufficient to influence many small farmers to make the change. They may be deterred by fears of disease, lower yields and the lack of sufficient standings to house extra cows.

Farmers who reject the idea of changing over to purchasing replacements have still the alternative of rearing fewer replacements and keeping more cows, since a surplus of replacements is often reared.

If, in this example, the average herd life of the cows was lengthened to five years, the requisite number of followers to keep the herd self-maintained could be reduced by one-third. This would make it possible to keep extra cows which would earn about £250 more profit.

### *Other Alternatives*

On farms where lack of buildings precludes the replacing of followers with cows, there may still be a case for changing to buying replacements if there are other enterprises which could be expanded profitably.

On small dairy farms in the North certain alternative methods offered greater possibilities because they fitted easily into the farming system, but would not necessarily be suitable for all areas.

The first case quoted was of a 50-acre farm in Durham where the substitution of purchased replacements for home-reared ones released 10¼ acres of land for other use. As the machinery and labour were already available, it was decided to grow 5 acres of potatoes and 5 acres of wheat for sale. A partial budget for this change is given below.

*Farm A. Budgeted effect of replacing followers with cash crops*

| EXTRA COSTS | £ | COSTS SAVED | £ |
|---|---|---|---|
| Fertilizers for 5 acres potatoes 10 cwt per acre @ £22 per ton | 55 | Fertilizers for crops replaced | 68 |
| Potato seed 18 cwt per acre @ £24 | 108 | Seed for crops replaced | 2 |
| Wheat seed for 5¼ acres 10 stones per acre @ £40 | 13 | Bought food for young stock | 65 |
| Harvesting potatoes | 52 | EXTRA REVENUE | |
| Contract combining and baling | 37 | Potatoes @ £108 per acre | 540 |
| Extra fuel | 14 | Wheat @ £35 per acre | 185 |
| 4 herd replacements | 328 | Milk fed to calves now sold | 4 |
| | | Calves retained now sold 4 @ £13 | 52 |
| | 607 | | |
| Extra family income | 309 | | |
| | £916 | | £916 |

On a second farm (B) 16·2 acres would be freed by the decision to buy in replacements, and the suggestion was to introduce a flock of 30 ewes (maintained by purchasing replacements) from which all the lambs are sold fat. At prices ruling in 1958–59 the budgeted change was as follows:

*Farm B. Budgeted effect of replacing followers with ewe flock*

| EXTRA COSTS | £ | COSTS SAVED | £ |
|---|---|---|---|
| 12 Gimmers @ £10 | 120 | Bought food for young stock | 25 |
| Depreciation on ram | 5 | | |
| Haulage | 3 | EXTRA REVENUE | |
| 3 Dairy herd replacements @ £82 | 246 | 48 Fat lambs @ £8 | 384 |
| | | 10 Cost ewes @ £5 | 50 |
| | 374 | Wool | 33 |
| Extra family income | 160 | Milk prev. fed to calves | 6 |
| | | Calves retained now sold 3 @ £12 | 36 |
| | £534 | | £534 |

The author concluded that the change from rearing to buying replacements could often mean considerable extra profit on small dairy farms. The added income would depend partly on the system of rearing adopted and partly on the alternative use that was made of the resources released. There would be wide variations in the amount of extra income earned and, on any one farm, the decision should be reached only after taking into account "the possibility of some drop in milk yield per cow, a fall in prices received for cows sold out of the herd, a rise in the cost of cows purchased, an increase in the number of replacements needed, and a reduction in the number of calves born.

"When all these factors have been allowed for, the likely addition to profit will not always seem enough to outweigh the risk of introducing disease into the herd. There must, however, be many small dairy farmers who, by continuing to rear their own dairy heifers, pay a very high premium for limited security against disease."

## IV. Self-feeding Systems for Silage

There has been growing interest in the self-feeding of silage and a study of this practice in the South-West was carried out by Langley and Beynon in 1957–58[19] and 1958–59[20]. The 1957–58 study concerned 30 farms, two-thirds of which were over 100 acres in size. Twenty-four of the farms were mainly dairy farms and self-fed silage to dairy cows, 6 self-fed silage to young stock or beef stores. The sample covered all the principal dairy breeds and all appeared amenable to this form of feeding.

For self-feeding, various types of silo were used including clamps, pits, and covered and uncovered surface silos. The majority were, however, covered surface silos which had been built under the silo subsidy scheme. Table 35 gives some costs of erecting silos.

TABLE 35. *Covered surface silos—cost per 1 ton of capacity according to total capacity of silo*

| | Number of farms | Average capacity | Average gross cost | Average gross cost per ton capacity |
|---|---|---|---|---|
| | | *tons* | £ | £ |
| Up to 100 tons | 2 | 90 | 377 | 4·2 |
| 101–150 tons | 5 | 145 | 510 | 3·5 |
| 151–200 | 7 | 187 | 477 | 2·5 |
| 201 tons and over | 4 | 312 | 817 | 2·6 |
| Total | 18 | 193 | 550 | 2·9 |

The average cost per ton capacity of an uncovered silo was £1. Gross costs on covered silos varied from 30*s*. 0*d*. to over £5 per ton capacity, depending on the additional features considered necessary, for example, a concrete feeding apron.

Although some farmers combined the self-feeding of silage with cowhouse milkings, a bail or parlour system combined with loose housing was more common. The average lying space allowed was 40 sq. ft per cow, this required an average of ½ cwt of bedding per cow per week. The exercise area was about 70 sq. ft per cow. No seal was used on the silage in over one-half of the covered silos.

The buckrake was still the most popular form of harvesting machinery. In this sample, there were 19 buckrakes on farms which made an average of 98 tons of silage per farm. One farmer used two or even three buckrakes to make a large tonnage.

From the survey it was estimated that the average quantity of silage actually self-fed was 128 tons per farm. This allowed for wastage and hand-feeding. The simple average quantity of silage consumed per cow per day was 84 lb, although the range between farms was extremely wide, from under 30 to over 120 lb per cow per day.

"Several significant factors influence the daily intake of silage, the more important being:

*a*. other bulky foods fed with silage;
*b*. time the cows are allowed access to the silage;
*c*. width of feeding face per animal;
*d*. control fence on the feeding face.

"Other factors include the height of feeding face, the effect of lacerated silage as opposed to long stemmy material, the ease of approach to the feeding face including the condition of the surface area around the feeding face."

The following table shows the effect that the feeding of other bulky foods had on the consumption of silage, and indicated that the estimated limits to dry matter intake were frequently surpassed.

TABLE 36. *Classification of 24 farms according to the other bulky foods fed with self-fed silage*

| Feeding practices | *Number of farms* | Average consumption per cow per day | | |
|---|---|---|---|---|
| | | *Silage lb* | *Kale lb* | *Hay lb* |
| 1. Grazed kale by day for most or all of self feeding period (generally night access to silage) | 15 | 75 | 50–60 | 4–5 lb on 10 farms<br>Nil on 5 farms |
| 2. *No kale* but over 10 lb of hay per day | 4 | 82 | nil | 12–14 |
| 3. *No kale* and *no hay* except for kale in first week or two on some farms | 5 | 112 | nil | nil |

On the majority of farms access to self-feed silage was mainly restricted to night-time, with kale being grazed by day, although a quantity of the herds were allowed continuous access. No conclusions were drawn as to the most satisfactory system.

The importance of good access to the silage face was emphasized. It was found that if cattle were required to struggle through hock-deep mud and slime to reach the face they consumed less than they should and lost condition.

An analysis of winter feeding practice showed that the most common bulk rations of either silage alone, or silage and kale, or silage and hay all provided sufficient theoretical nutrients for maintenance and two gallons of milk. The average yield of 22 herds was 722 gallons. The production actually achieved from bulky foods was about ⅔ of a gallon per cow. This measure was derived from both low and high-yielding cows including the dry cows in the herds. Assessing the contribution of bulky foods in another way, the sample farms fed 2·7 lb of concentrates per gallon during the self-feeding period, as against a 'general' usage of 4 lb or more per gallon during the winter period.

In 1958–59 the consumption of concentrates was influenced by wet weather, which prevailed from the early spring and resulted in poor quality hay and silage. Thus the level of feeding remained fairly high throughout the winter. Despite this, however, cows in the self-fed herds received only 9·6 cwt of concentrates as against 11·6 cwt in a group of herds which were not self-fed.

The authors considered the labour-saving aspect to be one of the strongest arguments used in favour of self-feeding silage, and in this survey care was taken to isolate the labour-saving contingent on self-feeding as opposed to the usual advantages of a loose housing system. If silage were cut and carted to the average herd, 32 cows, it was estimated that 2·15 man hours and 2·0 tractor hours per day were required. With self-feeding, about 20–30 minutes per day were spent cleaning up at the feeding face and moving the feeding fence if any, so that the final saving consequent on self-feeding was about 1·65 man hours during the winter self-feeding period. A fence at the feeding face was not thought to be necessary in all cases but on 15 farms out of 24 some sort of barrier was used, usually in order to keep a tidy face or to prevent cows from climbing on to the heap rather than to ration the silage.

On 15 farms in this survey silage was successfully fed to stores and young dairy stock. The average daily intake of yearlings was 62 lb per head, and with some hay this amount theoretically contained sufficient nutrients for a liveweight increase of 1¼ lb per day. For two year olds the average consumption was 92 lb.

Will it pay to introduce self-feeding? The first year's report concluded with a budget form to help farmers answer this question for themselves. The report on the second year's investigations considered the introduction of self-feeding on a 150-acre farm. This farm carried a herd of 30 cows with average yields, silage was previously fed at the rate of 50 lb per day, the farmer introduced self-feeding in 1957–58 when an extra 50 tons of silage were made. The budget for the effect on his farming system looked like this:

Profits per gallon, which are, of course, additional to those already earned by producing milk, could be expected to range from 1½d. to nearly 4½d. depending on output and excluding the value of whey. "Profits in making super grade cheese are likely to be greater than those, but all the evidence suggests that the manufacture of grade II cheese holds out little prospect of additional profit for the milk producer. For real success in farmhouse cheesemaking the farmer must obtain either a high price for his product, or a good premium open factory cheese or preferably both. This can only be achieved with cheese of top quality."

Langley emphasized the importance of milk quality in another article[22]. Drawing on the experience of one well-known farmhouse cheese producer he showed how the spring drop in the solids content of milk affected the profitability of cheesemaking, since it was the total solids content of the milk which largely affected the conversion rate. In addition, when milk of poor keeping quality was used for cheesemaking, as for instance during a hot summer, the grades of the cheese were low.

Langley used this farmhouse example to highlight the importance to the national farm of quality in milk. He considered that, although there might be no overt need for a quality payment scheme for milk for liquid consumption, about 30 per cent of milk sold off farms in England and Wales went for manufacturing and this proportion was increasing. It was certain, therefore, that the composition of milk and its improvement would be of increasing importance in the future.

## VI. Linear Programming and the Dairy Farm

### *Linear Programming*

Linear programming is a mathematical technique to assist management in decision making. Using a computer to do the necessary sums, it is possible to calculate the scale and interrelationships of several business activities and farm enterprises and to determine the combination which would give maximum profit.

In practice, farmers and, in fact, all entrepreneurs, are not completely free to do as they wish. Restrictions on land, labour or capital will eventually limit the expansion of a farm business. In addition to ultimate restrictions, there are often other factors which prevent an entrepreneur from devoting all his resources solely to the production of his most profitable product. In farming rotational practices, good husbandry, tenancy agreement, building and machinery shortages are but some of these factors. The technique of linear programming allows account to be taken of these limitations or rigidities when it is used to determine the most profitable organization of an individual farm. The weakness of this method of planning is that, in spite of the mathematical precision of its answers, its results depend on numerous assumptions and forecasts about yields, prices, average weather conditions, etc.

TABLE 39. *Present and optimum organizations*

| PHYSICAL DATA | PRESENT PLAN | | | OPTIMUM PLAN | | |
|---|---|---|---|---|---|---|
| Crops | Acres | Per cent of Ploughland | | Acres | Per cent of Ploughland | |
| Wheat | 15·93 | 27·46 | | 19·31 | 35·00 | |
| Barley | 15·93 | 27·46 | | 13·23 | 23·98 | |
| Oats | 7·12 | 12·28 | | — | — | |
| Beans | 5·83 | 10·05 | | — | — | |
| Peas | — | — | | 8·28 | 15·00 | |
| Sugar beet | 4·73 | 8·16 | | 4·85 | 8·79 | |
| Mangolds | 1·93 | 3·33 | | 2·18 | 3·95 | |
| Clover | 6·53 | 11·26 | | 7·33 | 13·28 | |
| | 58·00 | 100·00 | | 55·18 | 100·00 | |
| Pasture | 23·00 | — | | 25·82 | — | |
| | 81·00 | | | 81·00 | | |
| Livestock | | | | | | |
| Dairy cows | | 14·38 | | | 16·22 | |
| Young cattle | | 12·33 | | | 13·90 | |
| Pigs | | 18 weaners fattened | | | Fixed at same level | |
| Poultry | | 100 laying hens | | | | |
| Horse | | 1 | | | | |
| FINANCIAL DATA | | | | | | |
| Receipts | £ | £ | £ | £ | £ | £ |
| Cereals | 983 | | | 1,024 | | |
| Soil improvers | — | | | 323 | | |
| Roots | 290 | | | 298 | | |
| | | 1,273 | | | 1,645 | |
| Milk | 1,826 | | | 2,059 | | |
| Cattle | 231 | | | 261 | | |
| Pigs | 410 | | | 410 | | |
| Poultry | 305 | | | 305 | | |
| | | 2,772 | | | 3,035 | |
| | | | 4,045 | | | 4,680 |
| Costs | | | | | | |
| Feeds | | 843 | | | 1,271 | |
| Seeds | | 192 | | | 187 | |
| Fertilizer | | 99 | | | 100 | |
| Livestock | | 228 | | | 231 | |
| Labour | | 785 | | | 779 | |
| Contract | | 89 | | | 82 | |
| Implements | | 438 | | | 438 | |
| Fuel | | 217 | | | 222 | |
| Rent | | 126 | | | 126 | |
| Overheads | | 231 | | | 246 | |
| | | | 3,248 | | | 3,682 |
| Net income | | | £797 | | | £998 |

The importance of linear programming for the average farmer is as the progenitor of the "Gross margin" or "Gross profit" techniques, which are shortcut methods developed for advisory purposes by which large numbers of farmers can receive the benefits of this approach. These concepts are particularly useful when a farmer is considering a re-organization of his farm. For instance, the gross margin approach may simplify the budgeting stage when a farmer is wondering whether to expand one enterprise at the expense of another or possibly to introduce a new line. However, it should be remembered that these simplified procedures derive from linear programming and, occasionally, university economists and others carry out formal exercises using the full technique. Three such studies have been conducted recently and each of them concerns the reorganization (within a basic framework) of a farm with a substantial dairy enterprise.

Barnard and Smith in two articles[23 and 24] describe the "programming" of an 84-acre arable dairy farm in the Eastern Counties. Thirty-seven acres were cash cropped with wheat, barley and sugar beet, there were 23 acres of permanent pasture and 21 acres of forage crops, oats, beans, mangolds and clover hay. There were 14 Friesian-type cows with yields of around 800 gallons, and the dairy herd provided about one-half of total revenue of the farm. There were numerous limitations on the optimum allocation of resources. Firstly, not all of the permanent pasture was ploughable; secondly, there was a rotational limitation on the acreage of cereals; sugar beet was limited by the existing contract, etc. The most important limitation was the amount of labour available at the peak periods, sugar beet hoeing, cereal harvesting and root harvesting, and the number of man hours required or available had to be included in the model. The possibility of adding another enterprise can be catered for and the growing of peas for canning was introduced as a possible source of additional profit. The proposed solution, if the various assumptions were accurate, should yield a total revenue of £2,414 (net of variable costs). This sum was achieved by changing the organization of the farms in the following way: land was taken from barley, oats and beans and put into peas, wheat, sugar beet, and more grass and fodder crops to feed the dairy herd, increased to 16 cows. The labour saved on the former enterprise was nearly sufficient to cope with the new organization, only 13 extra hours were needed, and a little extra capital was required to buy or rear the extra cows and to establish the extra grass. Table 39 shows the changes proposed.

Another paper, by Shirley Vincent[25], used linear programming to estimate the maximum net profit of a dairy enterprise. It was assumed that this enterprise was only part of the farm plan and no restrictions were placed on labour and capital. One hundred acres of available land were assumed and the problem turned on the rate of stocking and general organization of this acreage. A number of fodder crops, for example, hay, silage, aftermath grazing, kale, mangolds, oats and beans, were considered according to nutrient content, variable costs and the period of the year for which they would be available. Purchased dairy cake, oats and beans were also included in the matrix. The exercise produced the optimum programme (Table 40).

This optimum plan was, however, adjusted because of the impracticability on many farms of grazing kale after the end of December. A consequence of this new restriction was to reduce the number of cows from 68·4 to 62·6 and net profit from £2,532 to £2,382.

TABLE 40. *The optimum programme determined by the exercise*

| Crops: | Acres |
|---|---|
| Marrow-stem kale (September–mid-October) | 4·0 |
| Marrow-stem kale (mid-October–December) | 12·2 |
| Folded kale (January–March) | 25·2 |
| Folded kale (April) | 7·0 |
| 1 cut of silage (August) and aftermath grazing | 1·2 |
| Grazing | 50·4 |
| | 100·0 |
| Purchased foods: | |
| Oats purchased for consumption from May to August | 30·0 tons |
| Ground-nut cake purchased for consumption from September to April | 15·6 tons |
| Herd size | 68·4 cows |

# VII. The Farms of Dorset

Langley and Luxton[26] carried out an economic classification of Dorset farming on the basis of the 1953 June Returns. They found there were 3,079 full time farms in Dorset, and these farms were analysed by type of farming. 77·9 per cent of the farms occupying 79·3 per cent of the acreage were classified as Dairy farms. These were grouped as follows:

TABLE 41. *Classification of Dorset dairy farms*

| Type of group | Group No. | Farms | | Average size of farm (acres) |
|---|---|---|---|---|
| | | Number | Per cent | |
| *Dairy types* | | | | |
| Mainly dairy | 1 | 1,481 | 48·9 | 129 |
| Dairy with livestock | 2 | 720 | 23·8 | 153 |
| Dairy with crops | 3 | 157 | 5·2 | 409 |
| Total | | 2,358 | 77·9 | — |

Over half the farms in Groups 1 and 2 were under 100 acres, whilst over one half of the Group 3 farms had more than 300 acres. As might be expected, the average size of the dairy herd was in the small to medium range but there were also some large dairy farms in central and southern Dorset. A further interesting analysis indicated which was the most popular combination of enterprises. The definition used was that any farming activity could be classed as an enterprise if it contributed more than £100 output or alternatively 6 per cent of total farm output.

On this basis it was found that most farms combined 2 or 3 enterprises.

On the majority of smaller farms, dairying was usually associated with pigs and/or poultry, on the larger farms a crop enterprise either added to or replaced one of the latter.

Slightly over one-half the land in these type groups was under permanent grass and 14 per cent under temporary grass. The proportion of temporary to permanent grass was three or four times greater on the largest farms than on the very small. Cash roots were not important on Dorset farms but a substantial acreage of cereals was grown. The following table shows the variations in the farming pattern.

TABLE 42. *Distribution of farms by combination of enterprises within size groups. Dairy farms (groups 1, 2 and 3)*

| Combination of enterprises | Under 20 acres | 20 and under 50 | 50 and under 100 | 100 and under 150 | 150 and under 300 | 300 and under 500 | 500 and over | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | *Number of farms* | | | | |
| Dairy only | — | 55 | 60 | 27 | 24 | — | — | 166 |
| Dairy, pigs | 15 | 65 | 35 | 3 | 15 | — | — | 133 |
| Dairy, poultry | 30 | 165 | 170 | 99 | 24 | 6 | — | 494 |
| Dairy, pigs, poultry | 20 | 100 | 150 | 48 | 54 | 6 | — | 378 |
| Dairy, pigs, crops | — | 10 | 10 | 6 | 9 | 8 | 2 | 45 |
| Dairy, poultry, crops | — | 50 | 75 | 69 | 63 | 31 | 16 | 304 |
| Dairy, pigs, poultry, crops | — | 20 | 55 | 72 | 126 | 34 | 13 | 320 |
| Other combinations | — | 20 | 85 | 69 | 159 | 101 | 84 | 518 |
| Total | 65 | 485 | 640 | 393 | 474 | 186 | 115 | 2,358 |

The average rate of stocking with dairy cows over the three dairy groups was 18·7 per 100 acres. However, the range in stocking rates was wide and, whereas the 20–50 acre farms had a rate of 34·2 dairy cows per 100 acres, the farms of over 500 acres had only 11·2. The trend with the stocking of pigs and poultry was the same, with a higher concentration on the smaller farms. Only with sheep did stocking rate increase with farm size.

This report sketches the pattern of farming in a predominantly farming county, and provides the geographical and statistical data on which future studies can be based. Its statistics also emphasize the overwhelming predominance that the production of milk had in the farming of this part of the country.

# VIII. Trends in Milk Production

*South-West England* 1955–59

A brief review of conditions and changes in dairy farming in South-West England between 1955–59 was made by Bristol University.[27]

This period was marked by a high level of milk production supported by rising yields and increasing cow numbers, and was accompanied by a fall in the pool price. Policy changes on the individual farm were carried out against a background of Government and Milk Board exhortations to limit the amount of milk sold for manufacture at uneconomic prices.

The numbers of registered milk producers fell over the period, but there was an increase in cow numbers, providing evidence of the trend towards larger herds. Although milk sales fluctuated from year to year, the underlying trends were towards increased production. Yields too were on the increase, although the effect of bad weather masked this effect in particular years, as was shown by the marked fall in yield during 1958–59.

In 1957 the M.M.B. introduced the milk testing scheme in which producers, whose butter fat as recorded in monthly tests consistently falls below the 3·3 per cent minimum, would be liable to varying price penalties of up to 6*d*. a gallon.

The downward trend in basic prices was exemplified by the following table of annual average pool prices for the far west.

TABLE 43

| Year (April–March) | Guaranteed price *d*. per gal | Effective guaranteed price *d*. per gal | Actual basic price *d*. per gal |
|---|---|---|---|
| 1955–56 | 38·09 | 38·13 | 35·97 |
| 1956–57 | 38·50 | 36·76 | 34·67 |
| 1957–58 | 38·75 | 35·88 | 33·91 |
| 1958–59 | 37·75 | 36·70 | 34·02 |

The fall in prices, chiefly reflected through the operation of the standard quantity arrangement the increasing quantity of milk diverted to manufacturing at a low price. It was this trend, combined with that towards larger herds and the overall increase in production, which caused the Government, at the 1961 Price Review, to request the industry to devise some system of bringing home to producers the wide differential between the prices realized for liquid and manufacturing milk.

On the input side the factors of importance over the period were the increase in labour costs, largely offset by a reduction in labour hours per cow, and the reduction overall in the costs of purchased concentrates.

Against the background of these trends the authors analysed four years average costs from a small sample of south-western herds and concluded that, from 1955–56 to 1958–59, producers were combatting steadily falling returns by, on the one hand, cutting costs, and on the other, increasing herd size to maintain income. There was also some evidence of heavier stocking rates which resulted in an upward trend in margins per acre.

### '*The Farm Price and Supply of Milk*'

In this study[28] Gardner examined the supply response of producers to the price of milk. He demonstrated the inadequacy of analysis based on a straight price-quantity relationship during the period since the establishment of the Milk Marketing Board and also the inadequacy, in general, of relationships based on responses in single time periods. This led on to an exposition of distributed lag analysis, including some conceptional refinements.

For practicable calculations some simplification of these concepts proved necessary, and Gardner went on to consider the problem on a regional basis using the relative price of milk. "The use of regional material allows for the observation of local differences whilst the relative price appears to have two advantages over the recorded price. First, it does away with the apparent, but rather doubtful association of rising price and rising supply; second, it helps allow for the varying importance of milk in different areas." The index price of milk (1927–28 to 1929–30 = 100) was set against the index prices for cereals, roots and other crops, fat cattle, lambs and bacon pigs, roughly weighted by their regional importance. Computations for each region were carried out for a twelve-year period covering sales from 1947–48 to 1958–59. From these it would appear that the immediate response of milk supply to price change was small and of uncertain direction. The author's comment on this was "No clear pattern emerges, fortunately, from the statistical analysis and there is little temptation to rely upon answers of uncertain validity. Possibly, future investigations into problems of milk producers' responses will be more successful as additional material becomes available.

In addition to the statistical investigations Gardner examined recent data (1955–58) for any signs of tendencies or trends. He examined these on a county basis, first ranking the English mainland counties in three groups as shown in the following table:

TABLE 44

| Group | Number | Area | Land under grass | Land under permanent grass | No. occupiers in milk | Milk per acre per year |
|---|---|---|---|---|---|---|
| *a*) | 19 | Western | >66% | >50% | >50% | 90 gal or more |
| *b*) | 15 | Eastern | <50% | <30% | <30% | less than 50 gal |
| *c*) | ............... intermediate between *a*) and *b*) ................... | | | | | |

Within group *a*) he further distinguished a "dairy" group of those counties containing 35 per cent of the registered milk producers and producing 40 per cent of the total milk sales. Within group *b*) he distinguished an "arable" group (non-dairy) containing only 8 per cent of the registered producers who supply 9 per cent of the total milk sales, and with farms of a larger average size than in the dairy group. During the period 1955–58 there was a fall in the number of milk producers but the national dairy herd increased slightly by some 100,000 head. The number of milk producers declined whilst remaining producers enlarged their dairy herds. These changes were most marked in the "arable" counties with the result that there was increasing concentration of milk production in the "dairy" counties. Gardner considered that the main factors influencing producers to make these changes had been the relative fall in milk prices, the increase in grassland output, the effect of artificial insemination and the eradication of T.B. on milk yield per cow. He concluded that sharper price changes would be needed if price was to control output.

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| | |
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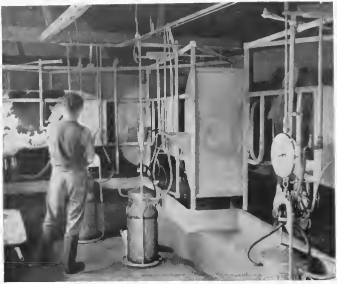
COWS AND ACRES

The rate of stocking has a major effect on the output of pasture. (p. 28).
(*Photo: Imperial Chemical Industries Ltd.*)

FARMHOUSE CHEESEMAKING

For real success, cheese must be of top quality. (p. 46).
(*Photo: Farmer and Stock-Breeder*)

PLATE IV



MEASURING MILK YIELDS

A good herdsman will adjust his feeding and management system to take account of the effect of diminishing returns (p. 20).

A PRODUCTIVE LEY

To be profitable, extra grass produced by manuring must be effectively utilized (p. 25).
*(Photo: Imperial Chemical Industries Ltd.)*

PLATE II

DAIRY FOLLOWERS

THE SALE RING

The decision to rear or buy replacements can have a marked effect on net income (p. 34).

*(Photos: Farmer and Stock-Breeder)*

PLATE III

A SIZEABLE HERD OF DAIRY COWS

Over the period studied farmers have tended to increase the size of their herds.

*(Photo: Imperial Chemical Industries Ltd.)*

PLATE I